Developing evidence on the primary case presentation and assessment of acute abdominal pain (colic) in the horse

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ABSTRACT

Abdominal pain (colic) in the horse is one of the most common emergency problems in the horse, but there are major gaps in the current evidence. Five original studies were undertaken to build evidence on the primary assessment of abdominal pain in the horse.

The first study was a systematic review of risk factors for abdominal pain. This identified 83 publications on risk factors for colic; 47 met inclusion criteria and were reviewed and categorised. Twenty four studies were evaluated using the JBI-Mastari critical appraisal tool. Evidence from the ten publications with least susceptibility to bias was collated. There was consensus of evidence for increasing age, recent change in diet and previous history of abdominal pain are risk factors for colic. This evidence should inform veterinary practitioner's clinical decision making and approach to disease prevention.

The second study was a systematic review of diagnostic tests for abdominal pain. This identified 190 publications; 46 publications met inclusion criteria and were reviewed and categorised. Thirty studies were evaluated using the QUADAS critical appraisal tool. None of the studies used a suitable methodology to assess the value of a diagnostic test to differentiate critical cases. The outcomes of this systematic review were a description of the current evidence and recommendations for future research using appropriate study designs.

Both systematic reviews highlighted a lack of evidence from primary practice.

The third study was a prospective survey of the primary assessment of horses with abdominal pain by veterinary practitioners. Data was collected from 1016 cases, including clinical history, presenting signs, diagnostic and treatment approaches and case outcome. Cases were categorised as critical or non-critical. Multivariate logistic regression was used to identify clinical features associated with critical cases. Five variables remained in the final model: pain, heart rate, capillary refill time, pulse character and gastrointestinal borborygmi. These should be considered essential components of the initial assessment and triage of horses presenting with colic.

The fourth study was an online survey of veterinary practitioner's opinions of diagnostic tests for colic. Responses from 228 participants were analysed. The most frequently used tests were 'response to analgesia', 'rectal examination' and 'nasogastric intubation', but there was a wide variation in practitioners' approaches. The main reasons for not using tests were that practitioners considered they were not required, or had concerns around personal safety, lack of facilities or financial constraints.

The final phase was two multi-disciplinary workshops to review current evidence and generate recommendations. Fifty participants attended the first workshop and generated 84 statements on the recognition of colic. Forty one participants attended the second workshop and

generated 160 statements on the assessment of horses with colic. These statements form the first phase of a multi-disciplinary Delphi process to develop best practice guidelines on the recognition and primary assessment of horses with abdominal pain.

This research makes significant contributions to the current evidence on abdominal pain in the horse. It has consolidated existing information, made recommendations for future research, and worked with practitioners to address evidence gaps, and involved different stakeholders in deciding how this evidence should be applied.

LIST OF PUBLICATIONS

*Please note the author's surname has changed from Issaoui to Curtis.

Curtis, L., Burford, J.H., Thomas, J.S.M., Curran, M.L.,Bayes, T.C., England, G.C.W. and Freeman, S.L., (in press) Prospective study of the primary evaluation of 1016 horses with clinical signs of abdominal pain by veterinary practitioners and the differentiation of critical and non-critical cases. *Acta Veterinaria Scandinavica*

Curtis, L., Trewin, I., England, G.C.W., Burford, J.H. and Freeman, S.L. (in press) Veterinary practitioners' selection of diagnostic tests for the primary evaluation of colic in the horse. *Veterinary Record Open*

Freeman, S. and Issaoui, L. (2013). Code red for colic: Decision-making for acute abdominal pain in the horse. *Equine Veterinary Education,* **25**(5): 245-246.

Freeman, S. L. and Curtis, L. (2015). Developing best practice guidelines on equine colic. *Veterinary Record,* **176**(2): 38-40.

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Jennings, K., Curtis, L., Burford, J. H. and Freeman, S. L. (2014). Prospective survey of veterinary practitioners' primary assessment of equine colic: clinical features, diagnoses, and treatment of 120 cases of large colon impaction. *BMC Veterinary Research* [Online], 10 Available: http://www.biomedcentral.com/1746-6148/10/S1/S2.

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I dedicate this thesis to all the horses and their owners affected by colic, including Albert, who was taken from me at the start of my PhD. If the Nottingham Colic Project can save one life by improving the recognition and diagnosis of critical cases of colic, I would consider that an enormous achievement.

“Do you give the horse his might?
Do you clothe his neck with a mane?
Do you make him leap like the locust?
His majestic snorting is terrifying.
He paws in the valley and exults in his strength;
he goes out to meet the weapons.
He laughs at fear and is not dismayed;
he does not turn back from the sword.
Upon him rattle the quiver,
the flashing spear, and the javelin.
With fierceness and rage he swallows the ground;
he cannot stand still at the sound of the trumpet.
When the trumpet sounds, he says ‘Aha!’
He smells the battle from afar,
the thunder of the captains, and the shouting.”

Job, Chapter 39 verses 19-25

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INTRODUCTION

The importance of the horse to Britain has altered over the past 500 years; its role has dramatically changed to compensate for our development from a "*horse drawn society*" to a country which utilises the horse for mostly sport and leisure purposes (Edwards, 2007). The United Kingdom (UK) is reported to contain approximately one million horses and ponies, with numbers of people engaging in the horse industry exceeding six million (D.E.F.R.A., 2004). The British Horse Industry Confederation states that an estimated £344 million is spent on equine healthcare per year, of which £254 million is devoted to veterinary fees (B.H.I.C., 2006). These figures illustrate the substantial role of the veterinary profession in the horse industry, and the combined impact of clinical decisions made by veterinary practitioners about horses across the UK.

Many health problems can seriously affect the horse and abdominal pain is a common cause for veterinary intervention; in some populations it is the primary cause of mortality (Traub-Dargatz *et al.*, 1991a; Tinker *et al.*, 1997a; Traub-Dargatz *et al.*, 2001). For this reason, there has been extensive research into the surgical aspect of abdominal pain in order to optimise the chances of survival (Donawick, 2004; Proudman *et al.*, 2005; Grzybowski *et al.*, 2011). Comparably less evidence is available about the primary assessment of abdominal pain despite the impact of the amount of time to referral on case prognosis (Singer and Smith, 2002). The diagnostic approach and assessment can be

challenging to the veterinary clinician (Dukti and White, 2009), and there are only two studies that discuss the diagnosis of abdominal pain in UK primary care populations (Proudman, 1991; Hillyer *et al.*, 2001).

There is a paucity of evidentiary support for veterinary practitioners involved in the primary assessment of equine abdominal pain in the horse, and limited knowledge about the decision-making process. In order to fill substantial gaps in the literature and involve veterinary practitioners to develop a methodology for incorporating the evidence into clinical practice, several original studies were undertaken. The following thesis will present five phases of work which will improve the evidence base and increase the current level of knowledge about the primary assessment of abdominal pain. They will demonstrate the facilitation of engagement and collaboration with veterinary practitioners in addition to horse owners in a method not previously documented. Findings from the five studies will combine and culminate in evidence-based, multi-disciplinary statements about the recognition and diagnosis of abdominal pain in the horse. These statements will be taken forward for the development of best-practice clinical guidelines to support veterinary practitioners in their decision-making in the primary assessment of abdominal pain.

Chapter One will present a critical review of the literature about evidence-based medicine, the significance of equine abdominal pain and the challenges posed to the veterinary practitioner in combining evidence with clinical practice. This review will introduce the subject

area and justify the work undertaken in the rest of this thesis. Risk factors for abdominal pain and diagnostic tests used by veterinary practitioners are two areas of significant research and will be briefly discussed in Chapter One, and systematically reviewed individually in Chapters Two and Three.

Chapter Four will describe a large prospective investigation of the primary assessment of cases of abdominal pain seen by veterinary practitioners in general practice. This phase of work will present information about cases currently seen in primary care practice; demographics, clinical history, presenting signs and the diagnostic and treatment approaches of the attending veterinary practitioner. The outcomes of cases will be described and associations between case presentation and severity will be investigated.

A survey of veterinary practitioners involved in the primary assessment of equine abdominal pain is presented in Chapter Five which will provide information about the diagnostic tests they preferentially use and any barriers and motivators to their selection of tests.

The planning and implementation of two multi-disciplinary workshops will be described in Chapter Six. Findings from Chapters Two to Five will be presented along with other research to veterinary practitioners, horse owners and other stakeholders, and will be incorporated into group discussions. Group consensus statements will be consolidated and described.

Recommendations for practice and/or future work will be made at the end of each chapter. The final discussion in Chapter Seven will incorporate findings from all the studies undertaken, discuss overall study design and limitations, along with the impact and implications of this thesis. Chapter Eight will present final recommendations for future work and conclude this thesis.

For clarification, within this thesis the term ‘colic’ is defined as equine abdominal pain of gastrointestinal origin. The terms ‘abdominal pain’ and ‘colic’ are used interchangeably throughout the document.

CHAPTER ONE: Literature Review

The objective of this chapter is to present an overview of the literature on evidence-based medicine; its theory, justification and implementation in the field of veterinary medicine. There will also be a review of the significance of equine colic and the evidence supporting the need for more research in this area. The chapter will introduce the reader to the literature on aetiology and veterinary decision-making in colic, but this will be investigated in more depth in Chapters Two and Three. This chapter is responsible for providing the reader with the impetus for the rest of the thesis.

1.1 Evidence-based medicine

Sackett *et al.* (1996) defined evidence-based medicine (EBM) as "*the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients".* The philosophy of EBM is that decision-making within clinical practice requires scientific underpinning in order to achieve consistent quality of care to medical patients (Cockcroft and Holmes, 2003; Timmermans and Mauck, 2005). This belief has caused some controversy within the medical profession, with some negative viewpoints of EBM. Some professionals highlighted the lack of (or difficulty accessing) relevant scientific evidence to support decision-making in certain conditions (Miettinen, 1998; Scott *et al.*, 2000). This concern cannot be directly attributed to the concept of EBM (Straus and McAlister, 2000); it is more about the practicality of translating the concept in order to apply it to practice. This criticism drove the quest for EBM to provide the medical profession with concise consolidation and appraisal of the best evidence available for a particular topic and therefore systematic reviews. Another concern was that EBM would negate the valuable role of practice-based experience, case studies and 'eminence-based' reports (Sinclair, 2004; Timmermans and Mauck, 2005), instead relying solely on best-evidence randomised-controlled trials (RCTs) which are not always applicable to 'real life' practice situations (Sarasin, 1999; Sinclair, 2004). In response to this criticism, it is recommended that EBM and also EVM (evidence-based veterinary medicine) are implemented via a multi-faceted approach; promulgation of best-evidence is not a replacement for

competence and experience, but a solid knowledge base on which to apply and integrate clinical expertise along with client preference (Sarasin, 1999; Scott *et al.*, 2000; Holmes and Ramey, 2007). With much deliberation over the role of EBM in both human and veterinary medicine, the requirement for well-constructed and peer-reviewed evidence-based research continues to rise exponentially (Imrie and Ramey, 2001). The British Medical Journal requires additional supporting evidence from authors wishing to submit any research which falls below the highest levels of study design (Fletcher *et al.*, 2012), and medical guidelines for well researched diseases such as renal cell carcinoma are being updated with more stringent acceptance of higher levels of evidence (Gough, 2007).

Evidence-based veterinary medicine (EBVM or EVM) is far behind the medical research industry in its development and there are several reasons for this, most notably the lack of considerable and consistent financial contribution to research. The Royal College of Veterinary Surgeons (RCVS) states "in order to be fit-to-practice, veterinary practitioners hold the responsibility to ground their decisions on sound, objective and up-to-date evidence, when available" (R.C.V.S., 2013a). There are often barriers to the application of EVM in practice which organisations such as the Centre for Evidence-Based Veterinary Medicine and RCVS Knowledge aim to address. Published veterinary research is not localised to one resource, in fact there are several sources of information, many of which require subscription at a cost. At the point of care, most veterinary practitioners do not have the time to

search through the mass of evidence and critically evaluate the quality of each source of information. An additional concern is the limited pool of evidence in some sectors of research, for example first-opinion practice, and notably the primary assessment of equine colic. One solution is to review the current research and critically appraise the available evidence for validity, to provide veterinary practitioners with results to apply in clinical context, and also to identify areas of further investigation and future research. This can be undertaken in the form of a systematic review.

1.1.1 Levels of evidence

The levels of evidence employed to practise evidence-based medicine are ranked in order of validity, strength of evidence and susceptibility to bias (Table 1). Randomised controlled trials are stated to have the most statistical power (Cockcroft and Holmes, 2003), but are not always prevalent within diagnostic or prognostic study reviews and so observational studies are 'upgraded' in such cases (O.C.E.B.M., 2011). Generally the levels of evidence remain consistent across literature appraisal (Cockcroft and Holmes, 2003; C.R.D., 2009; O.C.E.B.M., 2011), however levels of evidence tables have been created in order to assist researchers or clinicians identify which study type is superior depending on the research question (Merlin *et al.*, 2009). Figure 1 shows an example of a table that indicates which study types are most suitable to answer particular clinical questions (Vandeweerd *et al.*, 2012a). The introduction of bias can arise from dissimilar sources and

have a different impact depending on the study design; for example sampling bias in a retrospective case control study where it can be addressed through strict case selection is unlike that of a prospective cohort study where cases are not identified *a priori*.

Table 1 Levels of evidence and their relative sources as utilised in the practise of literature appraisal within evidence-based medicine. Adapted from Holmes and Ramey (2007) and (Bedenice, 2007)

Level of Evidence	**Sources**
One	The strongest type of evidence. Homogeneic systematic reviews of randomised controlled trials (RCTs), individual RCTs, complete-outcome case series ("all or nothing" results). Meta-analyses.
Two	Homogeneic systematic reviews of cohort studies (groups followed over time), individual cohort studies, research into the history of exposure in relation to the outcome of a cohort.
Three	Homogeneic systematic reviews of case-control studies, individual case-control studies.
Four	Case series, poor quality cohort and case-control studies (non-randomised, small sample size and/or study length, poor repeatability and reliability).
Five	The weakest type of evidence. Expert opinion commonly from clinical practice without supporting research or critical appraisal.

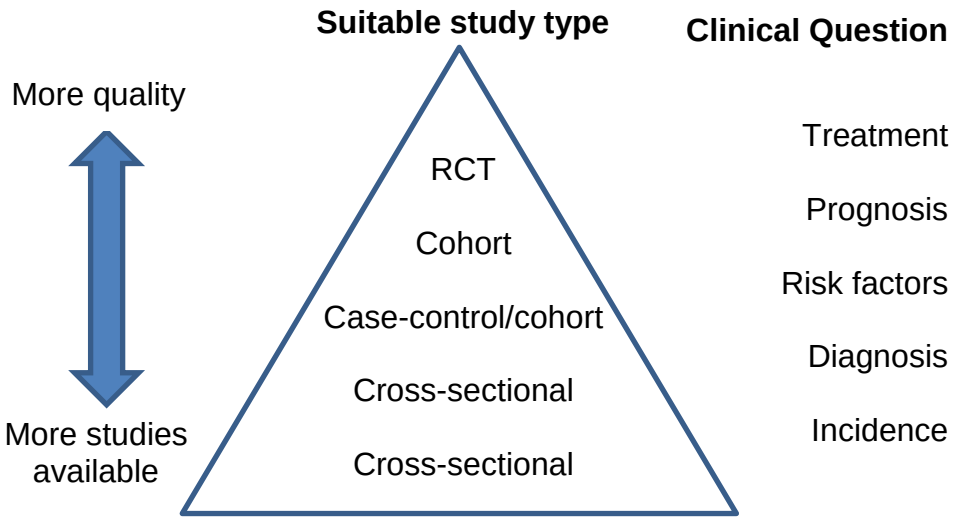


Figure 1. Optimum study types for particular clinical questions. Taken from Vandeweerd *et al.* (2012a)

1.1.2 Systematic review

A systematic review is a literature review performed to consolidate and critically appraise the research available on a chosen topic (Cook *et al.*, 1997; Sarasin, 1999). Systematic reviews aim to condense the mass of research into a succinct appraisal of the most useful and clinically applicable information, and highlight gaps in the research (Holmes, 2012).The process of carrying out a systematic review is fundamentally similar to any research project and begins with the formulation of a research question or objective (Egger *et al.*, 2001). Inclusion and exclusion criteria are established before the literature is thoroughly searched electronically using appropriate descriptive vocabulary or medical search headings (MeSH) of databases, article reference lists,

personal communication and through designated review registers (The Cochrane Collaboration, 2013). Each study which is identified from the literature search is checked for its eligibility against inclusion criteria, and if it meets this criteria it is critically appraised for methodological quality, validity and relevance using a predetermined appraisal/scoring tool (CASP, 2013). Data is collated from all the studies, or those that score most highly on appraisal. These are then analysed, presented, interpreted and finally disseminated (Torgerson, 2003). Data from homogenously comparable studies are statistically analysed to form a meta-analysis (this is not possible in studies with much variety in their methodology and results, i.e. heterogeneity). The result of this objective and exhaustive review is the synthesis of a singular document which contains the best available evidence and provides support for decision-making in practice (Miettinen, 1998; Sarasin, 1999; The Cochrane Collaboration, 2013).

A fundamental facet of any evidence-based medicine is the clinical question (Nolen-Walston *et al.*, 2007). It is important for a clinician to prioritise which are the most important issues to address the clinical predicament they are faced with. For example: 'Which question, once answered, will help make the decision whether or not to refer the case for surgery?' Another example would be: 'Based on the result of a particular test, what is the likely prognosis of the case?' A well-designed clinical question is directly relevant to the issue and phrased accurately enough to permit a precise set of results following a search of the literature (Richardson *et al.*, 1995). There is a growing body of evidence

in the human medical research field to answer specific clinical questions, including thousands of systematic reviews (Egger *et al.*, 2001; The Cochrane Collaboration, 2013).

There are several types of review, and terms used to describe each type of review are not consistent and can overlap on occasions. Each employs different methods to review the evidence depending on the clinical question and type and level of research available (for example qualitative, quantitative). Grant and Booth (2009) identified 14 main types of review, shown in Table 2. All types of review have advantages and disadvantages, but systematic reviews are considered the best quality and most robust type of review to answer a clinical question.

Table 2. Types of review, adapted from Grant and Booth (2009)

Review type	**Brief Description**
Critical review	Extensive research of the literature with critical evaluation of quality.
Literature review	General presentation and examination of recent or current published literature.
Mapping review	Identifies gaps in the literature by categorising literature in a specific subject.
Meta-analysis	Statistical analysis is applied to the results of quantitative studies to more accurately measure effect.
Mixed methods review	Combination of review types, usually with a literature review.
Overview	A general survey of the literature, with a rudimentary description of its characteristics.
Qualitative evidence synthesis	Comparative review looking at findings from qualitative studies.
Rapid review	A critical appraisal of literature using systematic methods.
Scoping review	The key concepts underpinning a research area are mapped with wide coverage of the available literature.
State-of-the-art review	Reviews current practice and literature as opposed to retrospective approaches.
Systematic review	Research is searched, appraised and synthesised systematically, often adhering to guidelines.
Systematic search and review	Critical review of the literature using a comprehensive search process.
Systematized review	Contains some elements of the systematic review process.
Umbrella review	Findings from multiple reviews are combined into one document.

Veterinary literature is also moving toward providing research-led reviews and guidelines for various aspects of specific clinical questions. These include systematic reviews of risk factors (Phiri *et al.*, 2010; Wylie *et al.*, 2012), diagnostic tests (Buczinski *et al.*, 2012; Sannmann *et al.*, 2012), treatments (Olivry and Mueller, 2003; Habacher *et al.*, 2006; Steffan *et al.*, 2006) disease and prevention (Pereira *et al.*, 2011; Paillot, 2013), and other aspects of veterinary treatment (Cockcroft and Holmes, 2003; Holmes and Ramey, 2007). Reporting guidelines help authors improve the execution and reporting of studies. They can also be used by researchers when undertaking a study to make certain their publication is worthy of inclusion to a systematic review. Reporting guidelines are available for randomised clinical trials (CONSORT) (Schulz *et al.*, 2010), diagnostic accuracy tests (STARD) (Bossuyt *et al.*, 2003) and observational epidemiological studies (STROBE) (von Elm *et al.*, 2008). These reporting guidelines are designed for medical studies but can usually be extrapolated to veterinary research effectively. They are important for ensuring consistency across studies of similar design which permits repeatability and therefore a stronger base of evidence. A validated, solid evidence base can be used to develop policies and guidelines to support clinical practice and decision-making.

Evidence-based policy making within health care research has been recognised as important since the 1990s with the first reference to evidence-based policies in 1990 (Mair and Mellor, 2005). Further references to the term EBM were published in 1993 (Sasaki *et al.*, 2008; Archer, 2009); evidence-based guidelines started to appear

around the mid-1990s and guidelines for guideline development were published in 1996 (Bowden *et al.*, 2014; R.C.V.S., 2015).

Guidelines are important in encouraging care recommendations to be based on the best available evidence. This contributes to a reduction in inappropriate variation in practice, and aids in identifying areas of primary focus for research and continuing professional development. Guidelines currently used in the medical field support the recognition of disease, for example the campaign that distribute symptom cards and have developed a mobile app of signs and symptoms of meningitis for potential patients and parents (www.meningitisnow.org). Other guidelines are designed to support healthcare professionals in the diagnosis of disease, for example the "Headsmart – Be Brain Tumour Aware" campaign which aims to improve the diagnosis of brain tumours in children (www.headsmart.org.uk). The National Institute for Health and Care Excellence (NICE) produces evidence-based guidelines and develops quality standards for the health profession with currently over 300 published guidelines (N.I.C.E., 2014).

Despite the wide use and availability of guidelines in human healthcare, there is a lack of similar guidelines for many areas of veterinary medicine. Consensus statements have been generated and distributed in preparation for the development of guidelines in small animal medicine (Littman *et al.*, 2006; Marks *et al.*, 2011; Sykes *et al.*, 2011), and there have been guidelines developed in areas of canine and feline medicine such as systemic hypertension in dogs and cats

(Brown *et al.*, 2007), canine atopic dermatitis (Olivry *et al.*, 2010) and leishmaniasis in dogs (Paltrinieri *et al.*, 2010). The United States of America (USA) have dominated the production of consensus statements and evidence-based clinical guidelines, which are distinctly lacking in the UK. Limited funding is likely to be a main reason for this; however there are UK organisations such as the Centre for Evidence-Based Veterinary Medicine working towards building the evidence needed to generate consensus statements for evidence-based clinical guidelines. UK and USA medical guidelines are heavily reliant on systematic reviews which are recognised as important in the development of best-practice guidelines (Silagy *et al.*, 2001).

The Cochrane Collaboration (www.cochrane.org) was established in the UK (Oxford) in 1993 with the remit of carrying out systematic reviews within health care research to objectively inform the decision-making of healthcare professionals. Before this, critical appraisal and systematic research syntheses (originally named meta-analysis) were being published from 1979 (Glass and Smith, 1979). The QUOROM (Quality of Reporting of Meta-Analyses) statement was developed in 1996 to provide reporting guidance to authors of meta-analyses of RCTs (meta-analyses are systematic reviews of studies which are statistically homogenous to allow analysis) (Cockcroft and Holmes, 2003; Liberati *et al.*, 2009). The QUOROM statement then changed to the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) in 2009 to incorporate systematic reviews (Moher *et al.*, 2009). The PRISMA statement consists of a 27 point checklist and flow

diagram with the aim of assisting authors in the reporting of systematic reviews of the benefits and harms of a healthcare intervention (Moher *et al.*, 2009). Checklists such as PRISMA require authors of systematic reviews to appraise important aspects of included studies such as study design, methods of minimising bias and statistical analysis. This is commonly achieved by using a critical appraisal tool.

1.1.1.2 Appraisal of study quality

Critical appraisal of the literature is used to objectively assess the different components of a research study, and to use these to generate an overview of the strengths and weaknesses of each piece of evidence. A critical appraisal tool ensures that the study design and methodological quality are considered as a matter of high priority during article analysis. Cockcroft and Holmes (2003) stated that higher grading using a level of evidence hierarchy reflects the statistical power of a study, although C.R.D. (2009) point out that the study type is not necessarily a pre-determinant for quality, and studies must be reviewed individually on a range of quality criteria before exclusion. The quality assessment criteria for the information available may vary depending on the feature of the clinical question, for example risk factor studies will have different methodological requirements to that of a study of diagnostic test accuracy.

Some critical appraisal tools integrate a scoring system in order to quantify the strength of evidence and prioritise the 'best evidence'. Two approaches to quantitatively scoring publications commonly used are

numeric scoring and rating totals. The first system uses numerical scoring whereby each quality component is given a scored rating which is then totalled to give an overall score per paper, or criterion is equally scored and all checked items add up to give an overall score (Table 3).

Table 3. An example of a quality assessment critical appraisal system using numeric scoring. Taken from van Tulder *et al.* (2000).

Reference	1a	1b	2a	2b	3	4	5	6	7	8	9	10	Total
Altmaier[1]	–	–	+	+	–	–	–	–	–	+	+	–	4
Basler[4]	+	–	–	–	+	–	–	–	–	+	+	–	4
Bru[7]	?	?	?	?	?	–	–	–	–	?	?	–	0
Bush[8]	?	?	+	?	?	+	+	–	–	?	+	–	4
Donaldson[11]	?	?	?	–	?	–	–	–	?	+	–	+	2
Kole-Snijders[16]	+	+	+	–	+	+	+	–	+	–	+	+	9
Lindström[17–20]	+	+	+	+	+	–	+	–	+	+	+	+	10
Linton[21]	+	+	+	+	–	–	+	–	+	+	+	–	8
McCauley[25]	–	–	+	–	+	–	–	–	–	+	+	–	4
Newton-John[28]	–	–	+	–	+	–	–	–	–	+	+	–	4
Nicholas[29]	?	?	+	–	+	?	–	–	–	+	–	+	4
Nicholas[30]	?	?	+	+	+	?	–	–	–	?	–	–	3
Nouwen[31]	–	–	+	+	+	–	–	–	+	+	+	–	6
Rose[33]	–	–	–	–	–	–	–	–	–	–	+	–	1
Strong[36]	–	–	–	–	+	+	–	+	–	–	+	–	3
Stuckey[37]	?	?	–	–	?	+	–	–	–	?	–	–	1
Turner[47]	–	–	–	–	–	+	–	–	–	–	+	+	3
Turner[44]	–	–	+	+	–	+	+	–	–	–	+	+	6
Turner[45]	+	–	–	–	–	–	+	–	–	–	+	+	4
Turner[46]	–	–	–	+	–	+	+	–	–	–	+	+	5

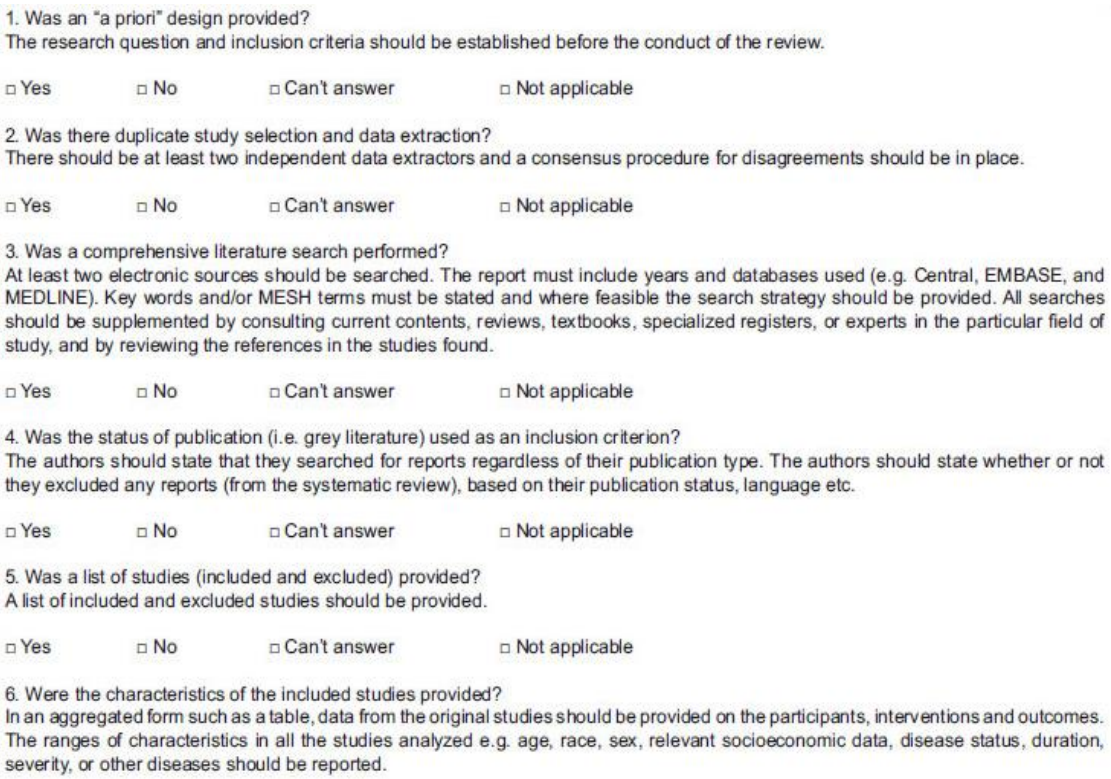
Weighting schemes, where each critical appraisal criterion is weighted based on its relative importance, are suggested by Crowe and Sheppard (2011) as a way to avoid sub-standard studies from 'hiding' within a summary score system. The most 'important' criteria would therefore be scored higher to ensure that the studies with the highest overall score had met with the most crucial aspects of study quality. An example is shown in Table 4.

Table 4. An example of a weighted scoring system for the critical appraisal of publications in a systematic review. Taken from Yong and Shafie (2014)

Table 1. Modified Quality of Health Economic Studies (QHES) checklist. In this version, the 'scoring system' was modified to cater for the double barrelled items (questions/criteria and its respective scores in bold). A similar question/criteria and scores was added (in italics) for different types of analysis design or economic evaluation. The total points remained as in original version.

	Questions/ Criteria	Scoring system	score
1	**Was the study objective presented in a clear, specific, and measurable manner?**	**Clear, specific, measurable = 7** **Any two = 5** **Any one = 2** **None = 0**	7
2	**Were the perspective of the analysis (societal, third-party payer, etc.) and reasons for its selection stated?**	**(1) Perspective = 2** **(2) Reasons = 2**	4
3	**Were variable estimates used in the analysis from the best available source (i.e., randomized control trial - best, expert opinion - worst)?**	**Randomized control trial = 8** **Non-Randomized control trial = 7** **Cohort studies = 6** **Case-control/case report /case series = 4** **Expert opinion = 2**	8
4	If estimates came from a subgroup analysis, were the groups prespecified at the beginning of the study?	Yes = 1 No = 0	1
5	**Was uncertainty handled by (1) statistical analysis to address random events, (2) sensitivity analysis to cover a range of assumptions?**	**(1) statistical analysis = 4.5** **(2) sensitivity analysis = 4.5**	9
6	Was incremental analysis performed between alternatives for resources and costs? *If the case is CBA, then the question shall ask "Was net monetary benefit / cost benefit ratio performed between alternatives for resources and costs?"*	Yes = 6 No = 0 *CCA type of economic evaluation = NA*	6
7	Was the methodology for data extraction (including the value of health states and other benefits) stated?	Yes = 5 No = 0	5
8	**Did the analytic horizon allow time for all relevant and important outcomes? Were benefits and costs that went beyond 1 year discounted (3% to 5%) and justification given for the discount rate?**	**If less than 1 year, only answer for the time horizon. Yes=7, No=0; If more than 1 year, done for** **(1) Time horizon = 3** **(2) Cost discounting = 1** **(3) Benefit discounting = 1** **(4) Justification = 2**	7

The second system commonly used to critical appraise studies assesses the presence or absence of an element of the study with the use of “Yes”, “No”, “Unclear” (for example) rating for each quality criterion. An example is the AMSTAR assessment tool for oral healthcare interventions which is shown in Figure 2 (Sequeira-Byron *et al.*, 2011)



1. Was an "a priori" design provided?
The research question and inclusion criteria should be established before the conduct of the review.

□ Yes □ No □ Can't answer □ Not applicable

2. Was there duplicate study selection and data extraction?
There should be at least two independent data extractors and a consensus procedure for disagreements should be in place.

□ Yes □ No □ Can't answer □ Not applicable

3. Was a comprehensive literature search performed?
At least two electronic sources should be searched. The report must include years and databases used (e.g. Central, EMBASE, and MEDLINE). Key words and/or MESH terms must be stated and where feasible the search strategy should be provided. All searches should be supplemented by consulting current contents, reviews, textbooks, specialized registers, or experts in the particular field of study, and by reviewing the references in the studies found.

□ Yes □ No □ Can't answer □ Not applicable

4. Was the status of publication (i.e. grey literature) used as an inclusion criterion?
The authors should state that they searched for reports regardless of their publication type. The authors should state whether or not they excluded any reports (from the systematic review), based on their publication status, language etc.

□ Yes □ No □ Can't answer □ Not applicable

5. Was a list of studies (included and excluded) provided?
A list of included and excluded studies should be provided.

□ Yes □ No □ Can't answer □ Not applicable

6. Were the characteristics of the included studies provided?
In an aggregated form such as a table, data from the original studies should be provided on the participants, interventions and outcomes. The ranges of characteristics in all the studies analyzed e.g. age, race, sex, relevant socioeconomic data, disease status, duration, severity, or other diseases should be reported.

Figure 2. An example of a rating system used in the critical appraisal of publications in a systematic review. Taken from Sequeira-Byron *et al.* (2011)

Veterinary research is significantly behind human medicine in terms of the quantity and quality of evidence. A rudimentary search using the VetSRev resource (www.nottingham.ac.uk/cevm/vetsrev) and the Cochrane Library (www.cochranelibrary.com) identified 177 veterinary *versus* 5563 (Cochrane Reviews only) meta-analyses published

between 1992 and 2015. This huge difference could be partly attributed to the lack of randomised controlled trials or comparable homogenous observational datasets in the veterinary literature.

1.1.3 Implementation of evidence-based veterinary medicine (EBVM)

Evidence-based veterinary medicine plays an integral role in promoting best practice and assisting in clinical decision-making. One area of practice where EBVM has demonstrated its impact is in emergency and critical care, where speed of decision-making has the potential to influence outcome. Clinical guidelines or recommendations have become vital tools in this aspect of the veterinary profession according to Burns (2013). The Reassessment Campaign on Veterinary Resuscitation (RECOVER), a collaborative effort of the American College of Veterinary Emergency and Critical Care and the Veterinary Emergency and Critical Society developed the first evidence-based guidelines to assist veterinary professionals in the cardio-pulmonary resuscitation (CPR) protocol in dogs and cats in cardiac arrest (Fletcher *et al.*, 2012). The knowledge gaps identified through this process have also led to the construction and implementation of evidence-based educational initiatives for veterinary practitioners and veterinary nurses working in triage (Brainard *et al.*, 2012) (Figure 3). By regular review and improvement of the recommendations whilst undertaking research to address knowledge gaps, CPR guidelines will encourage veterinary

health care professionals and researchers to strive for excellence for the good of the patient (Fletcher *et al.*, 2012).

- Perform 100-120 chest compressions per minute of one-third to one-half of the chest width, with the animal lying on its side.
- Ventilate intubated dogs and cats at a rate of 10 breaths per minute, or at a compression to ventilation ratio of 30 to 2 for mouth-to-snout ventilation.
- Perform CPR in 2-minute cycles, switching the “compressor” each cycle.
- Administer vasopressors every 3–5 minutes during CPR.

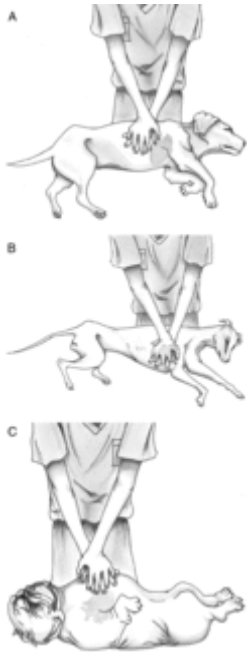


Figure 3. Example of recommended practice within evidence-based clinical guidelines for CPR in veterinary resuscitation (RECOVER) (Fletcher *et al.*, 2012)

The judicious use of current best evidence when making decisions in a clinical setting is commonly assumed to be occurring in veterinary practice. Veterinary practitioners are required to undertake regular continuing professional development (CPD) sessions and often subscribe to various veterinary journals in order to keep up to date on the latest advances. It is a requirement of the RCVS to do a minimum of 105 hours of CPD over a three year period with an average of 35 hours per year (R.C.V.S., 2015).

A busy clinician may however not have the time, experience or skills to critically appraise all the evidence on a particular aspect of a certain disease and arrive at a conclusion that can be used to make a conscientious decision about the care of each patient (Miettinen, 1998; Scott *et al.*, 2000; Cockcroft and Holmes, 2003). For this reason, evidence-based guidelines provide systematic research, appraisal and evaluation of the data available for a given clinical question (Straus and McAlister, 2000; Egger *et al.*, 2001). This reduces the time and study effort required, but also allows the veterinary practitioner to make an informed choice which they can defend with evidence if required (Holmes, 2012). As mentioned previously, evidence-based guidelines or recommendations also highlight gaps in evidence and knowledge which drives further research. In cases where there is limited or no evidence to base a clinical decision, veterinary practitioners must make their own judgement solely in view of their experience and anecdotal evidence, which as previously stated, is of low reliability according to the level of evidence hierarchy.

The equine industry in the UK is large, multi-faceted (Figure 4) and consumers are estimated at just under a quarter of the population (D.E.F.R.A., 2004), generating around £325 million for the UK Government in taxation revenue (R.C.V.S., 2013b). Research funding is prioritised to areas which will generate the most revenue or the most immediate impact. Horse racing for example, is a multi-million pound industry and funding is regularly distributed for research into infectious diseases, musculoskeletal disorders, racetrack design and

Thoroughbred breeding (H.B.L.B., 2015a). In terms of impact, equines were the fourth most common species seen as stated by veterinary practitioners performing clinical work, and the most common diseases were musculoskeletal and gastrointestinal (Nielsen *et al.*, 2014). Funding is provided to researchers to develop the evidence base on equine welfare issues such as joint disease and abdominal pain (WHW, 2015).

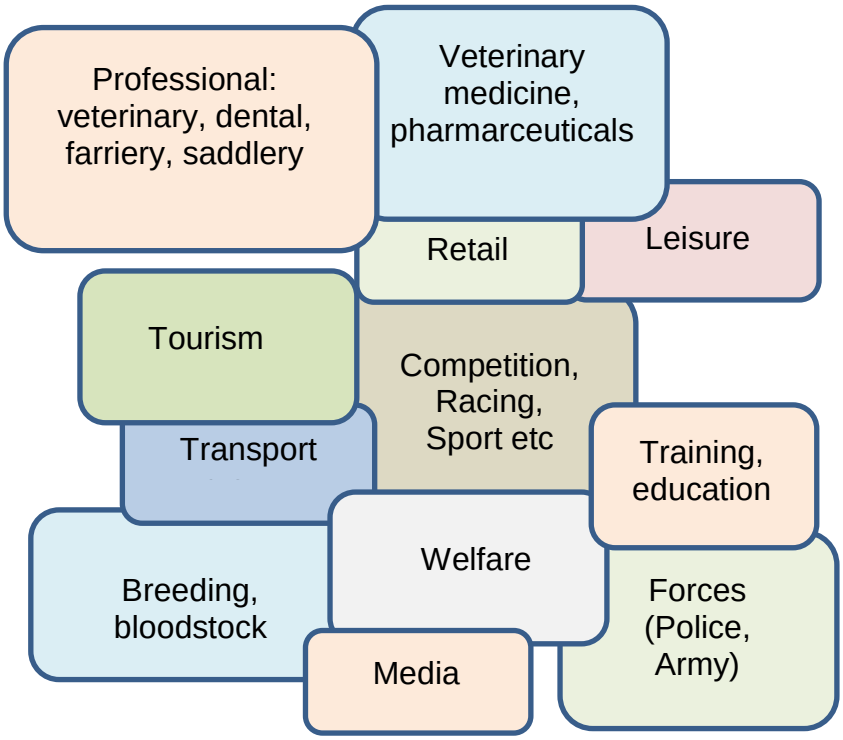


Figure 4. An overview of the sectors of the horse industry (D.E.F.R.A., 2004)

There is currently an increasing call within the field of veterinary research for specific clinical questions to be investigated in light of the best evidence available to provide guidance within veterinary practice (Marr, 2012). Well-controlled, standardised clinical trials are not commonly carried out in equine medicine and much of the research field within equine EBVM is built around individual cases and small to

medium scale observational studies (Cohen, 2003). Instead of large hospitals seeing large numbers of cases, there are smaller independent businesses each with their own data management system, and different approaches and treatments. This makes cross-practice sharing of clinical data infrequent and complicated and can lead to incongruent and diverse datasets. There is also no NHS equivalent and therefore a lack of 'big money' funding available within veterinary medicine research, however there are still some valuable cohort and case-control studies within the field of equine science (Vandeweerd *et al.*, 2012a). When they are performed, RCTs, cohort, cross-sectional and case-control studies are often based in controlled, possibly clinical environments (usually referral or University hospitals) and these studies are likely to form the basis of reviews (Cook *et al.*, 1997; Holmes, 2012). The availability of specialist equipment and/or facilities makes evidence-based guidance from these reviews much easier to follow in a similar environment; however more consideration is needed for the decision-making in first opinion practice.

1.2 The significance of abdominal pain in the horse

The term colic is described as the manifestation of visceral (abdominal) pain or discomfort as a result of pathological challenges to the alimentary system (Mehdi and Mohammad, 2006; Robertson and Sanchez, 2010). The signs of abdominal pain are usually related to pressure causing distension, and/or tension on mesenteric tissue and in some cases due to decreased blood supply (ischaemia), peritonitis or

infection to sections of intestine. These may be combined or individual causes of abdominal pain (Singer and Smith, 2002).

Colic is a multifactorial disease, and epidemiological studies have confirmed that abdominal pain in the horse is complex. The non-communicable nature of the disease adds complexity to recognition and diagnosis (Reeves, 1997). Studies investigating risk factors for abdominal pain have identified a large number of potential associations with colic in general (Reeves *et al.*, 1996; Cohen *et al.*, 1999; Hudson *et al.*, 2001) as well as specific types of colic such as small intestinal (Edwards and Proudman, 1994) and large intestinal disease (Dart *et al.*, 1992). Associations that have been suggested to increase the risk of abdominal pain in the horse can be divided into horse, management and environmental level risk factor categories. Suggested horse level risk factors include age (Tinker *et al.*, 1997b), breed (Cohen *et al.*, 1995) and behavioural traits (Malamed *et al.*, 2010). Some of the management factors potentially associated with abdominal pain are feeding practices (Hudson *et al.*, 2001), housing (Hassel *et al.*, 2008) and type of work of the horse (Hillyer *et al.*, 2001). Environmental factors investigated have included change in weather (Cohen *et al.*, 1999) and season (Archer, 2008).

Some reports of potential risk factors for abdominal pain in the horse have been consistent and others have been variable or contradictory (Tinker *et al.*, 1997b; Traub-Dargatz *et al.*, 2001). There are also variables which may confound the results of these studies, and the

levels of evidence may be too low to confidently interpret the findings with reference to the rest of the population. There has been no systematic review to provide an overview of the evidence base; however it is evident that the aetiology of abdominal pain in the horse poses a challenge to veterinary practitioners and horse owners. A systematic review of risk factors would provide clearer information about the evidence base.

Abdominal pain (colic), was considered the most important medical problem in horses by American equine practitioners (Traub-Dargatz *et al.*, 1991b), and has a high-impact both in terms of economy and welfare (Traub-Dargatz *et al.*, 2001; Egenvall *et al.*, 2008). A study by Tinker *et al.* (1997a) found mortality due to equine colic represented 28% (7/25) of all deaths; higher than that due to old age or injury (24% (6/25) and 8% (2/25) respectively). Overall mortality due to colic was lower in a study which assessed mortality in a geriatric population of horses in the UK and found mortality rates of 19.5%, (23/118) and lameness rates were also lower (23%, 27/118) according to Ireland *et al.* (2011). The aforementioned studies do not vary greatly in their findings despite originating from different countries (USA and UK respectively). A survey of all types of equine colic found a high mortality rate of 60.7% (Pascoe *et al.*, 1983); however this study was over 30 years ago, and there have been many subsequent advances in diagnosis, surgical technique and peri-operative and intensive care. More recently, a large prospective cohort study has recorded that 10.5% of all colic cases (n= 2055/ 21,591) died within 24 hours, with the

median survival of 54 days (range: 1 day to 7.6 years) for the remaining cases not lost to follow-up (n=1964), (M. Duz, personal communication, 2015).

The severity of colic varies, from many cases which resolve with little or no treatment and may not be reported to a veterinarian (Tinker *et al.*, 1997a; White, 2009), to 2-4% of cases which are likely to require surgical intervention for survival (White, 1990; Hillyer *et al.*, 2001). Even within the category of those that require surgical intervention, the aetiology and prognoses vary. Stephen *et al.* (2004a) reported that 41.7% of cases admitted to hospital with small intestinal volvulus did not survive. Of those treated surgically, 20.2% did not survive to be discharged. That study looked at a specific form of strangulating colic, however other studies looking at small intestinal lesions have also reported high rates of mortality such as 24.8% (Mair and Smith, 2005b) and 40.4% (Mezerova *et al.*, 2008b). Work performed more recently appears to have more accurate diagnosis of the cause of mortality but has focused on short-term survival, often only until discharge from hospital (Mair and Smith, 2005b; Sutton *et al.*, 2009; Southwood *et al.*, 2010). Even following surgical treatment, there is still a risk to the health and welfare of the horse. Recurrent cases of abdominal pain in the horse are one of the most frequently reported short and long-term complication following surgery according to Proudman *et al.* (2002b) and French *et al.* (2002). Mezerova *et al.* (2008a) found that 14.5% of surgical cases resulted in death/euthanasia due to post-operative complications. A reported total of 35% (67/191) horses suffered an

additional bout of colic following discharge after a single laparotomy (Mair and Smith, 2005a) and 10% of colic surgery survivors suffered from postoperative ileus a few days after surgery (Proudman *et al.*, 2002b).

There are many potential reasons for post-operative abdominal pain which presents a diagnostic and management challenge to the veterinary practitioner (Hart and Southwood, 2010). Intra-abdominal adhesions are an important complication of post-surgery recovery and were reported to be most common following small intestinal surgery (Mair and Smith, 2005a; Fogle *et al.*, 2008), surgery for right dorsal displacement (RDD) (Smith and Mair, 2010) and large colon torsion (>360 degrees) (French *et al.*, 2002). Published rates of adhesion formation vary across the literature however Mair and Smith (2005a) found that confirmed lesions were only reported in 17 out of 191 (8.4%) horses discharged after surgery which is comparable with the 6% rate of adhesions stated by Freeman *et al.* (2000). Other possible causes of the recurrence of abdominal pain following surgery include peritonitis, equine dysautonomia (grass sickness), enterolithiasis and gastric ulceration (Archer, 2009).

Recurrence of equine abdominal pain is not limited to post-operative cases but there is a paucity of studies investigating recurrent colic in non-surgical populations. It is reported to occur at a rate of 50 events/100 horse years according to a study of recurrence following a bout of medical colic in the general UK horse population by Scantlebury

et al. (2011). Those workers also identified risk factors for recurrence to be a known dental problem and oral stereotypic behaviour. Risk of recurrent or chronic intermittent colic was also investigated by Cohen and Peloso (1996) in a population of horses in Texas, USA. Risk factors identified by this USA study were previous abdominal surgery, age greater than eight years, feeding of coastal grass hay, Arabian breed and recent (within two weeks) change in stabling. The evidence for recurrent abdominal pain in the general UK horse population is limited and existing literature presents a wide range of risk factors for non-recurrent types and specific kinds of colic (such as post-operative colic) (Reid *et al.*, 1995; Little and Blikslager, 2002; Senior *et al.*, 2004) which may or may not be comparable. Abdominal pain in the horse presents the veterinary practitioner with a situation which is not always straightforward. There are also potential related complications; one of the main issues identified in the literature is recurrence of abdominal pain. Together these issues represent a significant impact on the health and welfare of the horse in addition to economic ramifications for the owner/carer (Archer, 2004).

1.2.1 The challenges of diagnosing equine abdominal pain

The challenge for the veterinary practitioner is to determine diagnosis (Archer, 2011) and provide appropriate treatment in as short a time as possible to optimise the outcome (Singer and Smith, 2002). A rapid diagnosis is of imperative importance for critical cases (those requiring intensive care and/or surgical intervention) and the duration of the

disease influences prognosis (Fischer, 1997; Beccati *et al.*, 2011; Busoni *et al.*, 2011). The decision to refer a colic case for surgery is built upon a variety of considerations – results of a selection of diagnostic tests, owner contribution (opinion, financial situation), use and value of the horse, and practitioner confidence and experience (Archer, 2004). The clinical examination carried out by the veterinary practitioner forms the first part of the case assessment, and normally includes a physical assessment of cardiovascular and respiratory function in addition to auscultation of the abdomen (Archer, 2004; Coomer, 2007; Orsini, 2011). Further tests may be warranted, but justification for the use of each test varies between veterinarians and no evidence-based guidelines currently exist. Atypical findings from clinical examination may provide justification for further diagnostic tests, however achieving a definitive diagnosis is difficult in many cases; often this can only be achieved through exploratory laparotomy or post mortem. A specific diagnosis was not made for 81% of cases investigated by Tinker *et al.* (1997a) and 72% of colic cases in a study by Proudman (1991) were either categorised as spasmodic or undiagnosed.

Many articles in the 1970s and 1980s discussed the diagnosis of equine abdominal pain and presented the variety of tests available at the time (Greatorex, 1972; Shideler and Bennett, 1976; Olsson *et al.*, 1977; Huskamp and Kopf, 1978; Davies, 1985; Wilson and Gordon, 1987b). None of these publications were clinical trials and were all based on books, anecdotal evidence and/or personal experience. As discussed

previously, this is a very low level of evidence and susceptible to bias. Since that time there have been a number of studies on diagnostic tests for colic such as ultrasound (Klohnen *et al.*, 1996; Beccati *et al.*, 2011; Grenager and Durham, 2011), blood sample parameters (Genn and Hertsch, 1982; Kaya and Iben, 2009; Cesarini *et al.*, 2010), abdominal paracentesis (Kobluk *et al.*, 1987; Freden *et al.*, 1998; Saulez *et al.*, 2004; El-Deeb and Fouda, 2011), rectal examination (Knottenbelt, 1989) and faecal egg count (Uhlinger, 1993). These studies are useful in identifying possible tests for colic, but have a number of limitations. There is a lack of research for diagnostic tests which specifically identify abdominal pain itself or tests which differentiate surgical from medical cases of colic. The data for most of these studies are also derived from referral populations and do not always discuss suitability of the test for the initial stages of a colic episode, or indeed the practicality of the test in the field.

There are numerous methods of diagnoses available to the first-line veterinary practitioner of a case of abdominal pain in the horse; unfortunately the level evidence supporting these tests is generally low and a systematic review of the literature is required.

1.3 Impetus for the study

Abdominal pain in the horse is a vitally important area for research due to the detrimental impact on equine health and welfare. Colic also presents emotional and economical challenges to horse owners, veterinary practitioners and other stakeholders. Much of the research in

equine abdominal pain is dated and the state of the current evidence base is unclear. Furthermore, bias towards referral populations has left a paucity of information about the primary assessment of colic. A generalised, multi-centric, prospective investigation of the veterinarian approach to first-opinion equine abdominal pain in general practice is required in order to address the gap in research, especially in the UK general horse population. This is needed to engage research with veterinary practitioners as well as horse owners to understand the challenges presented by colic in first-opinion practice. In addition to the lack of research into first-opinion colic in the horse, there is not enough primary research to support the use of many of the widely used diagnostic tests available to the first-opinion veterinary practitioner. This can not only be confusing for veterinary practitioners, but also hinders the progress of EBVM in practice. There is a need to explore, widen and improve the evidence on the use of diagnostic tests and their application in the initial assessment of equine abdominal pain with case outcome in mind. Recommendations on how to improve the quality of research conducted in colic are required to ensure valuable time and resources are spent on producing higher levels of evidence.

In the future, guidance must be provided for veterinary practitioners within first-opinion practice for the evidence-based, best-practice approach to the diagnosis of equine abdominal pain in the field. The standardisation of clinical practice guidelines is one way that evidence-based medicine can begin to be implemented within clinical practice

(Timmermans and Mauck, 2005). In order for guideline development in the future, the evidence base needs to be more substantial.

1.3.1 Aim and objectives

The aims of this project are to combine and also build evidence on the assessment of abdominal pain in the general horse population to develop evidence-based recommendations to support decision-making for veterinary practitioners in the primary assessment of equine abdominal pain.

In order to meet the above aims, the project has the following objectives:

1. To appraise and consolidate the current available evidence on risk factors for abdominal pain through a systematic review of the existing literature – Chapter Two.

2. To appraise and consolidate the current available evidence on the diagnosis of equine abdominal pain through a systematic review of the existing literature – Chapter Three.

3. To generate evidence on how cases of equine abdominal pain present at the initial evaluation by veterinary practitioners, the diagnostic approaches and treatments currently used, and the factors which influence clinician decision-making – Chapters Four and Five.

4. To develop a methodology to bring together equine health stakeholders in multi-disciplinary workshops, and to generate discussion and evidence-based statements about recognising and diagnosing abdominal pain in the horse – Chapter Six.

CHAPTER TWO: Risk factors for abdominal pain in the horse – A systematic review

This chapter meets the following objective: To appraise and consolidate the current available evidence on risk factors for abdominal pain through a systematic review of the existing literature

2.1 Introduction

The term colic is used to describe abdominal pain or discomfort, and manifests as a result of a disease or disorder of the alimentary system (Mehdi and Mohammad, 2006; Robertson and Sanchez, 2010). The causes of abdominal pain (colic) in the horse are often multifactorial. Therefore, identifying factors associated with an increased risk of colic is difficult to achieve through a single study (White, 2009). There have been many research attempts to identify factors associated with the increased risk of abdominal pain, with many research questions remaining unanswered. Some publications looked at factors associated with colic caused by a range of different diseases (Cohen *et al.*, 1995; Kaneene *et al.*, 1997; Mehdi and Mohammad, 2006), whilst others have investigated factors associated with specific diseases causing clinical

signs of colic (Newton *et al.*, 2004; Husted *et al.*, 2005; Archer *et al.*, 2008).

Consolidation of evidence through a systematic review will identify the best-evidence available, and highlight gaps in the current research (Collaboration, 2013), and contribute to evidence-based consensus statements.

The research question for this systematic review was: In equines (horses and ponies), does association with a particular horse, management or other factor (compared with no association) increase the risk of developing abdominal pain, (colic)?

The objectives of this review were:

- To identify literature on factors associated with the risk of developing abdominal pain (colic) in horses and ponies through a systematic search of databases.
- To evaluate the quality of evidence on factors associated with the risk of developing abdominal pain (colic).
- To summarise the best evidence on risk factors for equine abdominal pain (colic).

2.2 Methodology

This project was reviewed and approved by the Ethics Committee, School of Veterinary Medicine and Science, University of Nottingham. There were three phases to the systematic review, linked to each of the three objectives.

2.2.1 Systematic search of the literature

The primary literature search was conducted in CAB Abstracts (1910-2012), WEB of Science (1950-2012) and MEDLINE (1946-2012) (between 23-26/11/2012), using the following terms: (horses OR horse OR equine OR equines OR equus OR equidae OR equids OR equid) AND colic (which included abdominal pain). The results of each search were downloaded into bibliological software EndNote X6 (Thomson Reuters). Duplicates were searched for by author, title and reference and deleted within EndNote after each database search and extraction was completed. Publications were then assessed through three stages: review of titles for suitable publications, review of abstracts against inclusion and exclusion criteria, and review of the full publications. All titles within the EndNote library were examined, and their abstracts were reviewed, if the title included terms indicating risk, risk factors, causes, indicators, aetiology or predictors of abdominal pain or its associated diseases. Ambiguous titles were retained for further review at the next stage (review of abstract).

Abstracts from these publications were then independently assessed by two researchers (SF and LC) for agreement with inclusion and exclusion criteria (Table 5). Inclusion criteria related to causes of abdominal pain and study design. This systematic review was focused on publications of horses and/or ponies diagnosed with abdominal pain with any clinical outcome, including (but not restricted to) survival, surgery (including exploratory laparotomy), recovery, recurrence and euthanasia. Abdominal pain caused by different gastrointestinal diseases were included (e.g. gastric disease, small intestinal disease and recurrent abdominal pain), but non-gastrointestinal causes of abdominal pain were excluded. Appropriate study design for an investigation of potential risk factors was a criterion for inclusion. Cohort, case-control and cross-sectional publications were included. Case series results were retained in the initial overview of the literature, but were excluded from analysis. Publications were also excluded if they were not available in English, or were reviews or textbook chapters (Table 5)

Table 5. Inclusion and exclusion criteria for a systematic review of factors associated with an increased risk of equine abdominal pain.

Inclusion	**Exclusion**
Abdominal pain relating to diseases of the gastrointestinal tract	Abdominal pain arising from non-gastrointestinal causes
Single and recurrent episodes of abdominal pain*	
Abdominal pain occurring >30 days following abdominal surgery	Abdominal pain occurring <30 days following abdominal surgery
Studies relating to risk factors	No mention of risk factors, or not primary focus
All types of *Equus caballus*	Donkeys
Research presented in conference proceedings	Narrative reviews (including those in conference proceedings)
Peer and non-peer reviewed publications	Textbook chapters
Cohort, case-control and cross-sectional study design	Case series study design

Full text available**	Articles not in English

* A new case of abdominal pain was described as such if onset occurred at least seven days after the end of the previous episode (Hillyer et al., 2001).

**A study was included if full text could be obtained from any of the University of Nottingham libraries or e-libraries, through University of Nottingham journal subscriptions, during one of three visits to the British Library or from free online Open Access.

2.2.2 Evaluation of quality of published research

Publications remaining after review of the abstracts against inclusion and exclusion criteria, were then categorised as either 'General' (publications which related to clinical signs of abdominal pain across a range of different diseases) or 'Specific' (publications which related to specific diseases causing clinical signs of abdominal pain). Categorisation of publications into these two groups was carried out independently by two reviewers (LC and SF), who then discussed and agreed the final list of publications with the support of a third reviewer (JB). Any publications which were ambiguous were retained and categorised in the next step, the critical appraisal of the full publication.

The quality of the published research was evaluated in two stages: firstly by a descriptive analysis of the methodological features of the cohort, case-control, cross-sectional and case studies identified by the systematic search, and secondly by a quality appraisal of the cohort, case-control and cross-sectional studies.

2.2.2a The methodological features of the current published research, study design and study population

The methodological features of the publications identified in the systematic search were categorised into either the 'General' group or the 'Specific' group (as described previously). Two publications investigated 'recurrent colic' cases only, these included a range of different diseases, and were therefore considered to be a sub-category within the 'General' group. The publications in the 'Specific' group table were sub-categorised according to type of disease: small intestinal disease, large intestinal disease, gastric disease and grass sickness (both horse and premises measures). Analysis focused on cohort, case-control, cross-sectional studies, but case series were also analysed to review the body of evidence available. Methodological features that were assessed for each publication included study design, study population source, number of horses selected as a trial population, number of diseased horses extracted from the trial population, and factors associated with the risk of abdominal pain evaluated.

2.2.2b Quality appraisal of cohort, case-control and cross-sectional publications

Cohort, case-control and cross-sectional publications that met the inclusion criteria were focused on. The 'Specific' group publications were reserved for a separate study. The 'General' group publications were assessed by two independent reviewers (LC and SF) for methodological validity and susceptibility to bias. A standardised critical

appraisal instrument was used from the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI). This assessment tool is for comparable cohort and case-control publications (Figure 5). There is currently no appraisal tool for cross-sectional publications; these were evaluated using the same appraisal tool with the removal of criteria relating to follow up and minimisation of bias during selection of cases and controls (not relevant to cross-sectional studies). For each JBI-MAStARI criterion, publications were rated either 'Yes', 'No', 'Unclear' or 'Not Applicable'. The total number of 'Yes' ratings for each study were recorded as a measure of individual study methodological quality and an indication of susceptibility to bias between publications. Criteria attainment (total number of 'Yes' ratings minus all 'Not Applicable' ratings for each criterion) were recorded as a measure of methodological quality across all publications. Any disagreements that arose between the reviewers were resolved through discussion with a third reviewer (JB).

Quality assessment results, including total number of 'Yes' ratings and criteria attainment were placed in a table in order of study design superiority (cohort followed by case-control and cross-sectional) and then by the number of 'Yes' ratings.

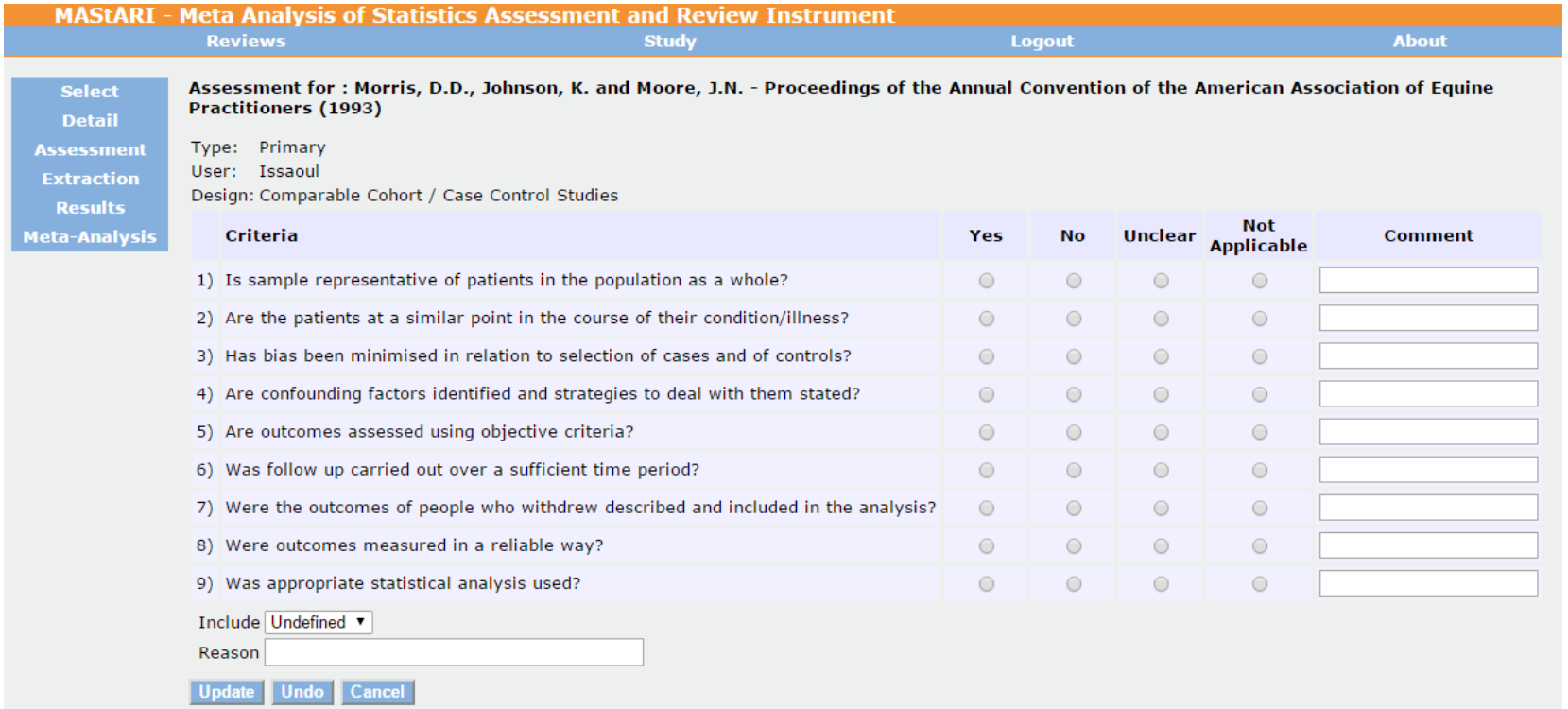


Figure 5. JBI-MAStARI critical appraisal tool: Comparable cohort/case control studies and adapted for cross-sectional studies.

Criteria 3) and 6) were disregarded when assessing cross-sectional studies.

Outcomes of Criteria 5) and 8) refer to the initial diagnosis of abdominal pain and not to the final outcome of each horse.

2.2.3 Summary of the best evidence on risk factors for abdominal pain.

Summary of the best available evidence was only applied to the best quality publications, specifically the cohort and case-control studies within the ‘General’ group. Publications relating to ‘Specific’ causes of abdominal pain were set aside to be studied as part of another project and therefore were excluded from this final analysis and summary of evidence. Cross-sectional studies are not best quality methodology for risk factor studies, and therefore were excluded from this final analysis. Cohort and case-control studies which attained seven or more ‘Yes’ ratings were selected; these represented publications with a relative low susceptibility to bias as demonstrated by Beauvais *et al.* (2012). Data from these higher scoring cohort and case-control publications were extracted and consolidated to provide a summary of the best available evidence. As there was clear variation between the publications, no statistical test for heterogeneity or quantitative meta-analysis were performed.

Any potential risk factors were considered in light of agreement between the publications. Consistent agreement between three or more ‘General’ abdominal pain publications including at least one cohort study was considered good evidence.

2.3 Results

2.3.1 Systematic search of the literature

A systematic search across the three databases identified 4062 publications. Titles and abstracts were screened for included terms indicating risk, risk factors, causes, indicators, aetiology or predictors of abdominal pain or its associated diseases which identified 83 publications to risk factors. Then the abstracts of these 83 publications were reviewed against inclusion and exclusion criteria which generated 47 publications (Figure 6).

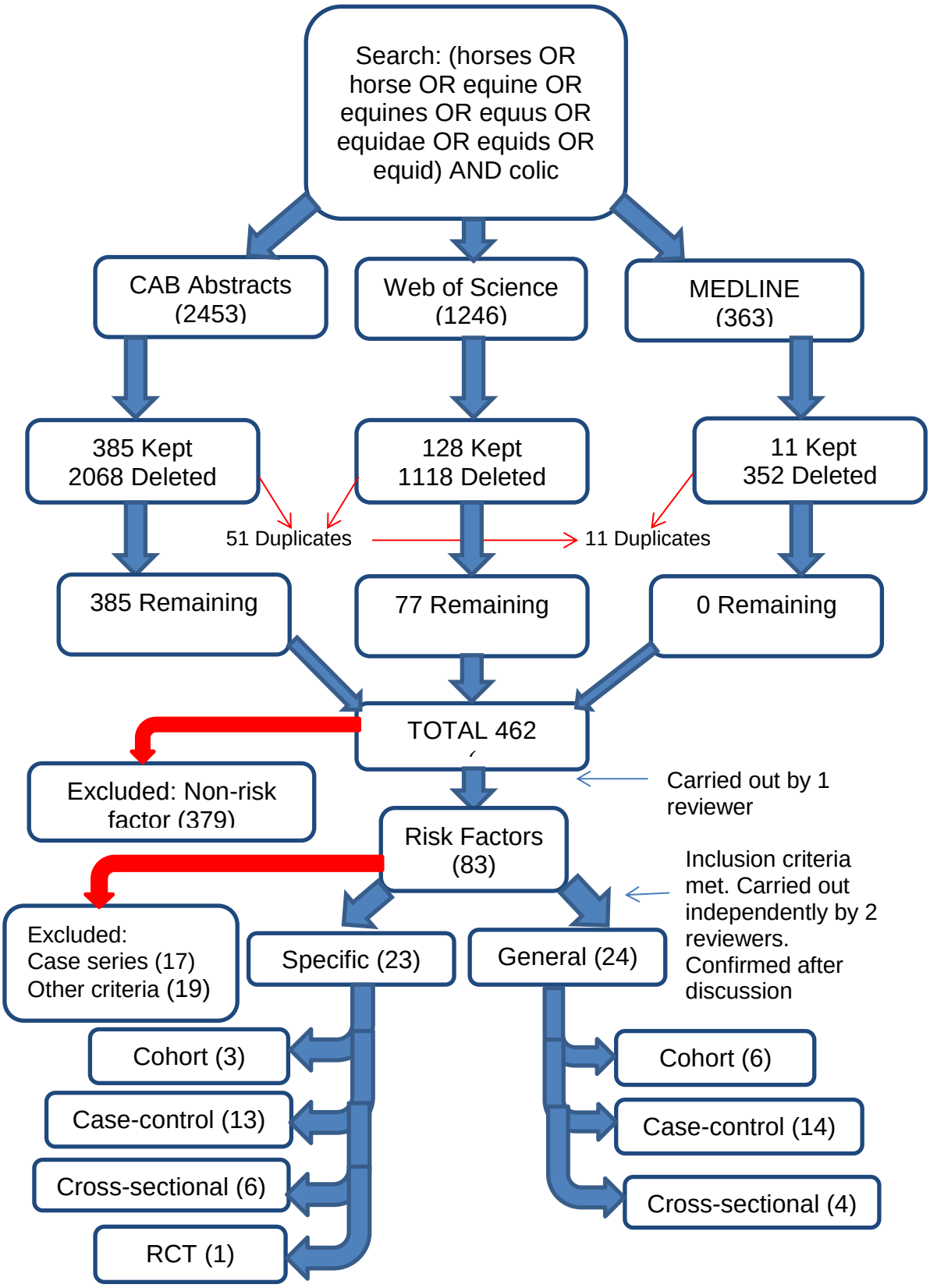


Figure 6. Literature search flow chart for a systematic review of risk factors for equine abdominal pain.

RCT = Randomised controlled trial

2.3.2 Evaluation of quality of published research

Of the 47 publications which met the inclusion criteria; 24 were placed in the ‘General’ group (publications which related to clinical signs of abdominal pain across a range of different diseases) and 23 were categorised as ‘Specific’ (publications which related to specific diseases causing clinical signs of abdominal pain.). There were two publications investigating recurrent colic which were sub-categorised within the ‘General’ group (Figure 6).

2.3.2a The methodological features of the current published research, study design and study population

Six publications were cohort study design, 14 were case-control, although Archer *et al.* (2006b) is strictly a nested case-control within a cohort but was categorised in this instance as a case-control design due to the assessed aspect of the study. Four included publications were of cross-sectional study design. The methodological features of the publications which met the inclusion criteria with the addition of excluded case series can be found in Tables 6, 7 and 8.

Table 6. Methodological features of 24 cohort, case-control or cross-sectional studies categorised as 'General' risk factor studies (publications which related to clinical signs of abdominal pain across a range of different diseases of colic).

Author	Study design	Colic diagnosis	Cases confirmed on surgery/ necropsy	Study population	Trial sample size	Number with colic	Risk factors evaluated
Sub group: All types of general abdominal pain							
Archer *et al.* (2006b)	Nested CC in Co	VS	Some	UK referral hospital	2580	2580	Seasonality
Cohen *et al.* (1999)	CC	VS	No	USA multi practice	2060	1030	Age, sex, breed, number of horses, acreage, density, housing, bedding, recent housing changes, diet, feeding practices, dental care, anthelmintics, immunisation, performance and activity level and changes, transport, history of previous colic
Cohen *et al.* (1995)	CC	VS	No	USA multi practice	1642	821	Age, sex, breed, number of horses, acreage, density, housing , bedding, recent housing changes, diet, feeding practices, water sources, weather, dental care, anthelmintics, activity amount and changes, history of previous colic
Egenvall *et al.* (2008)	RCo	VS	Unclear	Sweden insured horses	116,288	3100	Age, sex, breed, region, urban/other, life insurance value
Hillyer *et al.* (2001)	XS	VS/C	Unclear	UK Thoroughbred training yards	7757	509	Seasonality, premises, age, exercise, parasite control and carer
Hudson *et al.* (2001)	CC	VS	Unclear	USA multi practice	364	182	Age, sex, breed, feeding management, pasture management, water management and anthelmintic treatment

Kaneene *et al.* (1997)	XS	VS/C	Some	USA, equine farms	3175	62	Signalement, management (inc housing, use of horse) feeding, watering, anthelmintic treatment
Kaya *et al.* (2009)	CC	VS	Unclear	Italy, 1 referral hospital	2743	366	Signalement, management (inc housing, use of horse) feeding, watering, anthelmintic treatment
Leblond *et al.* (2002)	CC	VS	All at post mortem	Post mortems from Belgium, France, Germany, Switzerland, UK	842	421	Age, gender, parasitic lesions, breed
Malamed *et al.* (2010)	CC	VS	No	USA, 1 hospital, case caretakers	574	347	Demographic information, repetitive behaviours, behavioural traits and temperament
Mehdi and Mohammad (2006)	XS	VS	No	Iran, 6 race and endurance yards	128	128	Age, sex, breed, anthelmintic control program, nutritional status
Morris *et al.* (1989)	XS	VS	Some	USA, referral hospital	1937	229	Age, sex, breed, history, use, type, feed amount, recent feed change, stocking density, anthelmintics, history and incidence of previous colic, activity before onset
Patipa *et al.* (2012)	RCo	VS	Some	USA referral hospital cases on treatment for ocular disease	337	72	Age, sex, breed, ocular disease type, duration of ocular disease, hospitalisation time, subpalpebral lavage system, atropine, eye surgery
Proudman (1991)	CC	VS	Some	UK, general practice	279	179	Age, sex, duration of colic signs, mean monthly temperature, rainfall, historical events/ recent changes
Proudman and Edwards (1993)	CC	VS	Unclear	UK, faeces from referral cases	116	116	Tapeworm infection

Proudman and Holdstock (2000)	CC	Unclear	No	UK, 1 yard, flat and endurance horses	27	13	Age, breed, tapeworm flotation, ELISA optical density
Rabuffo *et al.* (2009)	CC	VS	No	USA referral hospital	169	112	Age, sex, breed, clinical laboratory data, anatomic site of lesion, gastric ulceration
Reeves *et al.* (1996)	CC	VS	Unclear	USA, 5 referral hospitals	812	406	Demographics, exercise, housing, environment, roughage nutrition, breeding history, veterinary care, health history, temperament, vices, transport
Tinker *et al.* (1997a)	PCo	O/C	No	USA, 31 yards	1427	86	Age, gender, breed, horse use, farm type
Tinker *et al.* (1997b)	PCo	O/C	No	USA, 31 yards	1427	86	Farm, horses, employees, feedstuffs, water, habitat, pasture, health. Horse, housing, use, nutrition, health history, events and changes during study
Traub-Dargatz *et al.* (2001)	PCo	O/C	No	USA, 1026 horse yards in 28 states	21820	Unclear	Age, sex, breed, use, date and duration of colic, treatment, cause if known, history of previous colic, feed type, water source, watering method, stocking density, dental care, anthelmintic use, season, faecal parasites
Uhlinger (1990)	CC cross-over	VS	No	UK, 4 privately owned herds.	Approx. 156	Unclear	Anthelmintic schedules; monthly and bi-monthly non-ivermectin, bi-monthly ivermectin
Sub group: Recurrent abdominal pain							
Cohen and Peloso (1996)	CC	VS	No	USA multi practice study population	1642	821	Age, sex, breed, farm acreage, farm density, housing management, feeding practice, recent management changes, dental care, anthelmintics, worming protocol, vaccination details, performance, activity level, transport, medical disorders, history of previous colic
Scantlebury *et al.* (2011)	PCo	VS/C	No	UK, horses with recent medical therapy for colic	127	127	Breed, owner of the horse, history of colic within 12 months, worming programme, dental problem, management change, number of horses, stereotypic behaviour, frequency chewing objects in stable, reaction to dentist and transportation, forage eating speed.

* VS = Veterinary practitioner - physical examination, diagnostic tests, or surgery or necropsy. VS/C = Veterinary practitioner and/or carer of the horse. O/C = Horse owner and/or carer. Co=Cohort, CC=Case-control, XS=Cross-sectional, RCo = Retrospective cohort, PCo = Prospective cohort

Table 7.Methodological features of 23 cohort, case-control and cross-sectional studies categorised as 'Specific' risk factor studies (publications which related to specific diseases causing clinical signs of abdominal pain).

Author	Study design	Colic diagnosis	Cases confirmed on surgery/ necropsy	Study population	Trial sample size	Number with specific disease	Risk factors evaluated
Sub-category: Small intestinal disease- epiploic foramen entrapment and/or lipoma							
Archer *et al.* (2004)	XS	VS	Yes	1 UK, 1 USA referral hospital. Surgical cases	789	68	Crib biting behaviour
Archer *et al.* (2008)	CC	VS	Yes	UK multicentre university and private clinic caseload. Owner questionnaire	293	77	Previous colic, person caring for the horse, stable or pasture, feed, seasonal time in stable/ pasture, exercise, recent changes in feed, stabling
Doyle *et al.* (2003)	CC	VS	Yes	2 UK, 1 USA hospital. Horses undergoing exploratory celiotomy	789	68	Crib biting behaviour
Edwards and Proudman (1994)	CC	VS	Yes	UK, 2 referral hospitals. Pedunculated lipoma cases	150	75	Age, sex, breed, lipoma weight
Freeman and Schaeffer (2001)	CC	VS	Yes	USA, 1 referral hospital. Horses anaesthetised for surgery.	125	29 lipoma, 17 EFE	Age

Sub-category: Small intestinal disease – ileal impaction, volvulus							
Little and Blikslager (2002)	CC	VS	Yes	USA, 1 referral hospital. Horses treated surgically for ileal impaction	278	78	Age, breed, sex, type of hay fed, concentrate feed information, anthelmintic prophylaxis (pyrantel)
Proudman *et al.* (1998)	CC	VS	No	UK spasmodic colic cases	228	123(103 spasmodic, 20 ileal impaction)	*Anoplocephala perfoliata* parasite infection intensity
Stephen *et al.* (2004b)	CC	VS	Some cases	USA, records of cases admitted	74,079	115	Age, breed, sex, previous colic, duration of pain before surgery, drugs administered, heart rate, respiratory rate, rectal exam, temperature, capillary refill time, mucous membrane colour, pain on arrival, gastrointestinal auscultation, gastric reflux, treatments, haematology
Sub-category: Large intestinal disease – enterolithiasis, descending colon disease, simple colonic obstruction and distension, sand colic							
Cohen *et al.* (2000)	CC	VS	Yes	USA, 1 clinic. Horses with enterolithiasis	130	26	47 variables including signalment, housing, feed, anthelmintic routine, previous history of colic, findings on physical exam, anamnesis and clinic-pathologic testing
Dart *et al.* (1992)	XS	VS	Some cases	USA, referral hospital. Horses with abnormal conditions of the descending colon over 10 years	38,994	102	Breed, age, gender, condition
Hillyer *et al.* (2002b)	CC	VS	No	UK, 2 referral hospitals, horses and owners	227	76	24 variables including type of establishment, number of horses, number of carers, breed, height, exercise details, recent changes in exercise, feed or housing, hours in stable/ pasture, bedding, diet and feeding regime
Husted *et al.* (2005)	RCo	Unclear	No	Denmark, 19 stud yards. Icelandic horses, faecal analysis	211	119 sand in faeces	Sex, age, condition score, soil type, pasture quality, feeding practice practice in the paddock, age, sex and body condition score

Sub-category: Gastric disease – Equine gastric ulcer syndrome (EGUS)							
Luthersson *et al.* (2009)	XS	VS	No	Denmark, 23 yards, 5 regions. Non-racing thoroughbreds	201	107 EGUS	Purpose/type/amount of work, stabling, bedding, time spent outdoors per day, type of paddock, availability of outdoor water, number of meals fed per day, intervals between meals, meal size, type of forage and appetite, starch intake
McClure *et al.* (1999)	XS	VS	No	USA, 50 show horses in active training	50	29	Disposition, fitness, appetite, lameness, Non-steroidal anti-inflammatory drug administration, age, hours trained, days away from home, hours transported, number of trips/shows, hay consumption
Murray *et al.* (1996)	PCo	VS	No	USA, Thoroughbred racehorses under 3 trainers at 1 racecourse	67	63	Age, gender, racing/ training activity, administration of medications
Nicol *et al.* (2002)	RCT	Observer	No	UK Thoroughbred foals	24	11	Crib biting behaviour, diet
Rabuffo *et al.* (2009)	CC	VS	Some cases	USA 1 referral hospital. Colic cases	169	117 EGUS	Age, breed, gender, haemotologic data, location of colic
Rabuffo *et al.* (2002)	XS	VS	No	USA Standardbred racehorses in training	229	145 EGUS	Age, sex, medication received
Sandin *et al.* (2000)	XS	VS	Yes	Sweden, necropsy records	3715	633	Breed, gender, time of necropsy, season, signs of colic, medical treatment, involvement of intestine/oesphagus/liver/pancreas, parasitism

Sub-category: Grass sickness/ equine dysautonomia (EGS)							
Doxey *et al.* (1991)	CC	Unclear	Unclear	UK, Horse premises with or without previous EGS, owner questionnaire	1793	218	Age, type of premises, breed, physical condition of cases, number of animals kept at premises, season, grazing schedule
Wood *et al.* (1998)	CC	VS	Some cases	UK, grass sickness cases, owner questionnaire	361	135	Stabling, age, sex, breed, height, diet, condition score, contact with EGS cases, change in pasture or premises, time since last EGS case, anthelmintic prophylaxis, stocking density
Sub-category: Grass sickness (EGS) - measurement of premises not horses							
McCarthy *et al.* (2004)	CC	VS	Yes	UK EGS confirmed sites	180	60 sites	Pasture management, disturbed pasture, previous EGS, soil nutrient content, other grazing species, pasture nutrient content and local weather conditions for 2 weeks prior to onset of disease
Newton *et al.* (2004)	Co	VS	Some cases	UK premises with previous EGS cases	305	100 recurrent EGS premises	Horse numbers on premises, presence of horses aged <2, premises type, number of stables, water sources, grazing details, soil type, supplementary hay and concentrate details, anthelmintic frequency, faeces removal, pasture management, other species on site.

* VS = Veterinary practitioner - physical examination, diagnostic tests, or surgery or necropsy. Co=Cohort, CC=Case-control, XS=Cross-sectional, RCo = retrospective cohort, PCo = Prospective cohort

Table 8. Methodological features of 17 case series identified by a systematic search of the literature on risk factors for abdominal pain in the horse.

Author	**Disease**	**Cases confirmed on surgery/ necropsy**	**Study population**	**Number horses with colic**
Abutarbush *et al.* (2005)	All types of colic	Some	USA, 1 referral hospital population	604
Alexander and Haines (2012)	Surgical colic	All surgery	Dubai, 1 referral hospital population, racing endurance horses	15
Archer *et al.* (2006a)	Idiopathic eosinophilic enteritis	Yes	UK, 1 referral hospital population	12
Fielding and Dechant (2012)	All types of colic	Some	USA, 2 hospital populations, Horses in endurance competitions	36
Hardy *et al.* (2000)	Nephrosplenic entrapment (NSE)	Some	USA, 1 referral hospital. NSE cases presenting with abdominal pain	161
Hassanpour *et al.* (2007)	All types of colic	Unclear	Iran, Horse farms	23
Hassel *et al.* (1999)	Enterolithiasis	Some	USA, 1 referral hospital. Horses with enterolithiasis	900
Hillyer and Mair (1997)	Recurrent colic	Some	UK, 2 hospital populations (first and second opinion)	58
Huskamp and Scheidemann (2000)	Recurrent caecal impaction (RCI)	Some	Germany, 1 referral hospital. Horses with chronic RCI associated with hypertrophy of muscle layers	96
Mair (2002)	Small intestinal obstruction	No	UK 1 referral hospital. Horses with abdominal pain after access to feedblocks containing molasses.	4
Mair and Hillyer (1997)	Chronic colic	No	UK, 1 referral hospital, 1 1st/2nd opinion practice	106
Reeves *et al.* (1989b)	All types of colic	Some	USA, 1 referral hospital population	314
Reid *et al.* (1995)	Cyathostomiasis	No	UK, 1 first opinion, 2 referral practices. Chronic diarrhoea cases	87
Vainio *et al.* (2011)	Primary gastric impaction	No	Finland, 1 horse hospital	20
Voigt *et al.* (2009)	All types of colic	Some	South Africa, 1 equine referral hospital	935
Walmsley *et al.* (2011)	All types of colic	No	Singapore, racehorses after swimming exercise	361

*VS= Veterinary practitioner – physical examination, diagnostic tests, or surgery or necropsy

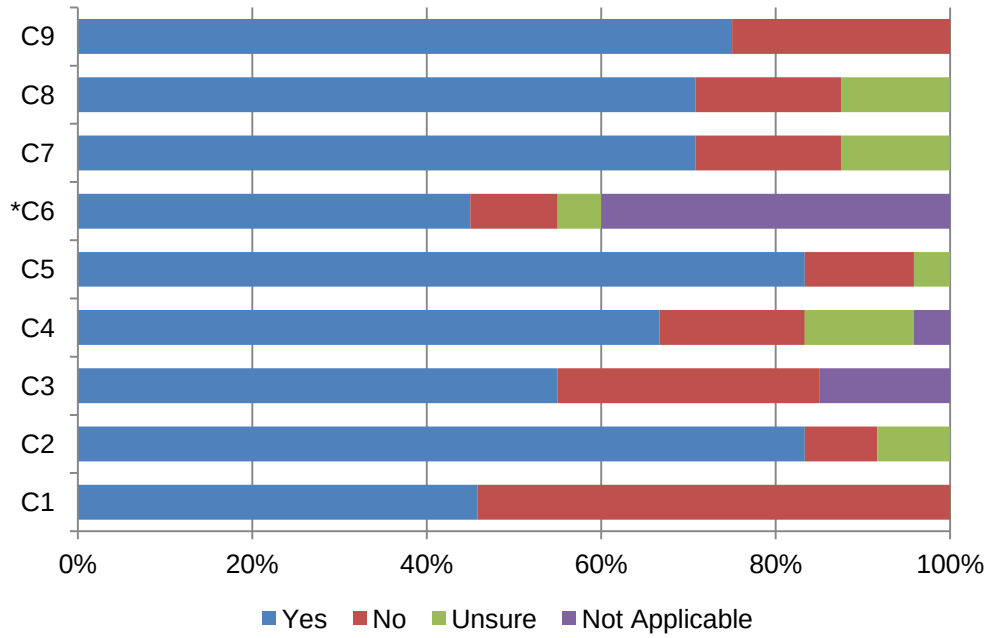
2.3.2b Quality appraisal of cohort, case-control and cross-sectional publications

Publications in the 'Specific' group were considered too heterogenous and were not assessed at this stage or included in the rest of this review. There were 24 publications in the 'General' group which were cohort, case-control or cross-sectional studies, quality assessed using the JBI-MAStARI critical appraisal tool. The number of 'Yes' ratings and level of criteria attainment within and between publications (Table 9 and Figure 7). The two most poorly attained criteria were JBI-MAStARI Criterion 1: 'Is the sample representative of patients in the population as a whole?' (45.8%) and JBI-MAStARI Criterion 3: 'Has bias been minimised in relation to selection of cases and controls?' (64.7%) The remaining criteria attainment ranged from 69.6% and 83.3%. The criteria most consistently met were JBI-MAStARI Criterion 2: 'Are the patients at a similar point in their condition?' and JBI-MAStARI Criterion 5: 'Are outcomes assessed using objective criteria?' (both 83.3%). JBI-MAStARI Criterion 6: 'Was follow up carried out over a sufficient time period?' was not applicable in 8/14 case-control publications due to the individual study design not requiring a follow up, and cross-sectional publications were not required to meet this criterion.

Table 9. Quality appraisal of 24 cohort, case-control and cross-sectional studies identified in a systematic review of risk factors for equine abdominal pain.

Papers	C1	C2	C3	C4	C5	C6	C7	C8	C9	Yes total
Cohort studies										
Tinker et al., (1997b)	Y	Y	N/A	Y	Y	Y	Y	Y	Y	8
Scantlebury *et al.,* (2011)	Y	Y	Y	Y	Y	Y	Y	N	Y	8
Traub-Dargatz *et al.,* (2001)	Y	Y	N/A	Y	N	Y	Y	Y	Y	7
Egenvall *et al.,* 2008	Y	Y	N	N	Y	Y	Y	N	Y	6
Patipa *et al.,*(2012)	N	Y	Y	Y	Y	N	N	Y	Y	6
Tinker *et al.,* (1997a)	Y	Y	N/A	N	Y	Y	Y	N	N	5
Case-control studies										
Cohen & Peloso, (1996)	Y	Y	Y	Y	Y	N/A	Y	Y	Y	8
Cohen *et al.,* (1999)	Y	Y	Y	Y	Y	N/A	Y	Y	Y	8
Cohen *et al.,*(1995)	Y	Y	Y	Y	Y	N/A	Y	Y	Y	8
Reeves *et al.,* (1996)	Y	Y	Y	Y	Y	N	Y	Y	Y	8
Archer *et al.,*(2006)	N	Y	Y	N/A	Y	Y	Y	Y	Y	7
LeBlond *et al.,* (2002)	N	Y	Y	Y	Y	N/A	Y	Y	Y	7
Malamed *et al.,*(2010)	N	Y	Y	Y	Y	N/A	Y	Y	Y	7
Hudson *et al.,* (2001)	Y	Y	N	Y	N	Y	Y	N	Y	6
Kaya *et al.,* (2009)	N	Y	N	Y	Y	N/A	N	Y	Y	5
Proudman & Edwards, (1993)	N	Y	N	U	Y	N/A	Y	Y	Y	5
Proudman, (1991)	N	Y	Y	Y	Y	U	N	Y	N	5
Uhlinger, (1990)	N	Y	N	N	Y	Y	N	Y	Y	5
Rabuffo *et al.,* (2009)	N	N	Y	N	Y	N/A	Y	Y	N	4
Proudman & Holdstock, (2000)	N	N	N	U	Y	Y	U	Y	N	3
Cross-sectional studies (7 criteria)										
Kaneene *et al.,* (1997)	Y	Y		Y	Y		Y	U	Y	6
Hillyer *et al.,*(2001)	Y	U		Y	N		Y	Y	Y	5
Morris *et al.,*(1989)	N	Y		Y	Y		U	U	N	3
Mehdi & Mohammad, (2006)	N	U		U	U		U	U	N	0
% of criterion attainment	45.8	83.3	64.7	69.6	83.3	75.0	70.8	70.8	75.0	

C1: Is sample representative of patients in the population as a whole? C2: Are the patients at a similar point in the course of their condition/illness? C3: Has bias been minimised in relation to selection of cases and controls? C4: Are confounding factors identified and strategies to deal with them stated? C5: Are outcomes assessed using objective criteria? C6: Was follow up carried out over a sufficient time period? C7: Were the outcomes of animals who withdrew described and included in the analysis? C8: Were outcomes measured in a reliable way? C9: Was appropriate statistical analysis used? Y=Yes, N=No, U=Unsure, N/A=Not Applicable.



C1: Is sample representative of patients in the population as a whole? C2: Are the patients at a similar point in the course of their condition/illness? C3: Has bias been minimised in relation to selection of cases and controls? C4: Are confounding factors identified and strategies to deal with them stated? C5: Are outcomes assessed using objective criteria? C6: Was follow up carried out over a sufficient time period? *Cross-sectional studies were not assessed using this criterion. C7: Were the outcomes of animals who withdrew described and included in the analysis? C8: Were outcomes measured in a reliable way? C9: Was appropriate statistical analysis used?

Figure 7. Combined quality assessment results for 24 ‘General’ colic publications in a systematic review of risk factors for equine abdominal pain.

2.3.3 Summary of the best available evidence on risk factors for equine abdominal pain (colic) in horses and ponies.

From the 24 cohort, cross-sectional and case-control publications in the 'General' abdominal pain group which were quality appraised using the JBI-MAStARI tool, the best performing cohort and case-control publications were selected. Case series studies were not summarised at this stage as they are not considered the best evidence. The best evidence was defined as those which attained a 'Yes' rating in seven or more critical appraisal criteria, therefore demonstrating a lower susceptibility to bias. Ten publications met this condition: Cohen *et al.* (1995); Cohen and Peloso (1996); Reeves *et al.* (1996); Tinker *et al.* (1997b); Cohen *et al.* (1999); Traub-Dargatz *et al.* (2001); Leblond *et al.* (2002); Archer *et al.* (2006b); Malamed *et al.* (2010); Scantlebury *et al.* (2011). The results of these publications were analysed and summarised to identify the best evidence available on factors associated with an increased risk of clinical signs of abdominal pain in the horse (Table 10). Consistent agreement between three or more studies of the best evidence publications found that the risk of abdominal pain in horses is higher with increasing age, Arab breed, recent change in diet, recent change in housing and in horses with a previous history of abdominal pain (Table 10).

The Age category was significant within two of the cohort studies; specifically increased risk between two to ten years (Tinker *et al.*, 1997b) and between six months to twenty years of age (Traub-Dargatz

et al., 2001). Both studies suggested that greater age increased the risk of abdominal pain, but the range at risk was too wide to interpret any further, and the publications used different ranges which was unhelpful for comparison. The case-control studies which assess age do not disagree with the cohort study findings in general, although the range at risk varied between studies. For the breed category, the evidence for the Arab breed as a risk factor for abdominal pain was consistent across three studies (Cohen and Peloso, 1996; Reeves *et al.*, 1996; Cohen *et al.*, 1999), but the evidence was based on case-control studies which are a lower level of evidence. There was no cohort study supporting this finding. The only cohort study to assess breed as a risk factor identified the Thoroughbred breed as higher risk (Traub-Dargatz *et al.* (2001).

Oral stereotypy (crib biting and windsucking) was not included in the list of consistent agreement, but was a factor which showed a positive association with an increased risk of equine abdominal pain, with a high odds ratio in the quality cohort study by Scantlebury *et al.* (2011). This finding was supported by one other case-control study (Malamed *et al.*, 2010). The evidence for this association was not large, which may be due to the lack of research in this area rather than the strength of the risk factor. This systematic review suggests that oral stereotypy may be a risk factor and should be investigated in future studies using a prospective cohort study design.

Feed and diet-related risk factors were investigated within several studies; only one cohort study explored and found evidence of a change in diet as a factor associated with an increased risk of abdominal pain (Tinker *et al.*, 1997b). This was supported by two case-control studies (Cohen *et al.*, 1995; Cohen *et al.*, 1999).

There was no cohort study in this systematic review which found a change in housing as a factor associated with an increased risk of developing abdominal pain, however there was a positive finding of an association in three case-control studies (Cohen and Peloso, 1996; Cohen *et al.*, 1999; Malamed *et al.*, 2010).

The evidence from one cohort (Tinker *et al.*, 1997b) and three case-control studies (Cohen *et al.*, 1995; Cohen and Peloso, 1996; Cohen *et al.*, 1999) suggest a previous history of colic as associated with an increased risk of further abdominal pain.

Table 10. Results of best performing included cohort and case-control publications in a systematic review of risk factors for abdominal pain in horses and ponies.

Category	Number studies /10	Author	Study design	JBI-MAStARI score /9	Risk factor identified (multivariable analysis where given) and measures of association
Horse factors		Tinker *et al.* (1997b)	Cohort	8	Age 2-10yrs (OR=2.8,95% CI=1.2-6.5, p=0.02) vs age <2yrs
		Traub-Dargatz *et al.* (2001)	Cohort	7	Higher incidence in 6mths to ≥20yrs compared with foals to <6mths (p≤0.009)
Age	7	Cohen *et al.* (1999)	Case-control	8	>10yrs (OR=1.5, 95% CI=1.1-2.0, p= 0.015)
		Cohen and Peloso (1996)	Case-control	8	*>8yrs (OR=1.52, 95% CI=1.29-1.79, p< 0.0001)
		Reeves *et al.* (1996)	Case-control	8	Increasing age ≥10yrs + dry lot use (10yr to 20yr = OR:1.9 to 7.4)
		Leblond *et al.* (2002)	Case-control	7	Compared with 0-1 yrs: 1-5yrs (OR=2.47, 95% CI=1.4-4.3, p=0.01) 5-10yrs (OR=4.43, 95% CI=2.54-7.71, p<0.001) 10-15yrs (OR=4.70, 95% CI=2.70-8.19, p<0.001) >15 yrs (OR=4.77, 95% CI=2.74-8.33, p<0.001)
		Malamed *et al.* (2010)	Case-control	7	20-24yrs (OR=2.85, 95% CI=1.38-5.88, p=0.0047) vs 1-4yrs

Gender	1	Leblond *et al.*, (2002)	Case-control	7	Higher in mares and geldings vs stallions (p ≤ 0.01)
Breed	5	Traub-Dargatz *et al.*, (2001)	Cohort	7	Higher incidence in Thoroughbreds (10.9 colics/year) vs 'stock' horses (3.5 colics/year, p=0.04) Higher incidence in Thoroughbreds (10.9 colics/year) vs other breeds (2.9 colics/year, p=0.03)
		Cohen *et al.*, (1999b)	Case-control	8	Higher in Arabs vs other breeds (OR=2.1, 95% CI=1.1-4.0, p=0.020)
		Cohen and Peloso, (1996)	Case-control	8	*Higher in Arabs + history of colic (OR=1.28, 95% CI=1.07-1.61, p=0.044)
		Reeves *et al.*, (1996b)	Case-control	8	Higher in Arabs vs Thoroughbreds (OR=2.0, 95% CI=1.0-3.9)
		Leblond *et al.*, (2002)	Case-control	7	Higher in Thoroughbreds vs heavy breeds (OR=4.09, 95% CI=1.18-14.13, p=0.04)
Temperament /Behaviour	2	Scantlebury *et al.*, (2011)	Cohort	8	History of crib-biting/ windsucking (OR=12.1, 95% CI=1.4-108.1, p=0.03 Speed eating forage (OR=3.6, 95% CI=1.2-10.9, p=0.02)
		Malamed *et al.*, (2010)	Case-control	7	History of crib-biting/ windsucking – age adjusted (OR=2.19, 95% CI=0.99-3.46, p=0.032)

Management factors Feed	5	Tinker *et al.*, (1997b)	Cohort	8	Concentrate intake of 2.5-5kg / day (OR=4.8, 95% CI=1.4-16.6, p=0.01) Concentrate intake of >5kg / day (OR=6.3, 95% CI=1.8-22.0, p=0.004) Whole grain fed (OR=0.4, 95% CI=0.2-0.8, p=0.01) 1 change in concentrate amount, type or frequency within 1 year (OR=3.6, 95% CI=1.6-5.4, p=<0.001) More than 1 change in concentrate amount , type or frequency within 1 year (OR=2.2,95% CI=1.2-4.1, p=0.02) More than1 change in hay within 1 year (OR=2.1, 95% CI=1.2-3.8, p=0.01)
		Cohen *et al.*, (1999b)	Case-control	8	Change in batch of hay within 2weeks (OR=9.8, 95% CI=1.2-81.5, p<0.05) Change of diet within 2weeks (OR=5.0, 95% CI=2.6-9.7, p<0.001)
		Cohen and Peloso, (1996)	Case-control	8	*Coastal grass hay (OR=1.34, 95% CI=1.06-1.70, p=0.012)
		Cohen *et al.* (1995)	Case-control	8	Change of diet within 2weeks (OR=2.21, 95% CI=1.74-2.79, p<0.001)
		Reeves *et al.*, (1996b)	Case-control	8	Whole grain corn (OR=3.40, 95% CI=1.45-7.83)
Exercise	1	Cohen *et al.*, (1999b)	Case-control	8	Exercise ≥ once/week (OR=1.6, 95% CI=1.2-2.2, p=0.003) vs pastured horses

Pasture	1	Reeves *et al.*, (1996b)	Case-control	8	Access to 4 pastures (OR=2.3, 95% CI=0.9-6.5) vs 1 pasture
Water	1	Reeves *et al.*, (1996b)	Case-control	8	No access to water (OR=2.2, 95% CI=1.2-4.3)
Housing	3	Cohen *et al.*, (1999b)	Case-control	8	Change of housing within 2 weeks (OR=2.3, 95% CI=1.2-4.1, p≤0.007)
		Cohen and Peloso, (1996)	Case-control	8	*Recent change in stabling (OR=0.76, 95% CI=0.61-0.96, p=0.044)
		Malamed *et al.*, (2010)	Case-control	7	Change of housing within 1 week (OR=3.93, 95% CI=2.64-5.84, p≤0.001)
Anthelmintic prophylaxis	2	Traub-Dargatz *et al.*, (2001)	Cohort	7	Horse part of an anthelmintic rotation programme (p<0.05) Horse part of a parasite testing policy (p<0.05)
		Cohen *et al.*, (1999b)	Case-control	8	Anthelmintic administration within 7 days (OR=2.1, 95% CI=1.1-4.0, p=0.018) Horse part of a regular deworming program OR=0.4, 95% CI=0.3-0.7, p<0.001) Horse NOT part of a regular deworming program (OR=2.2, 95% CI=1.4-3.3, p<0.001)
Previous Clinical History	5	Tinker *et al.*, (1997b)	Cohort	8	History of colic in last 5 years (OR=3.6, 95% CI=1.9-6.8, p<0.001) vs no history of colic
		Cohen *et al.*, (1999b)	Case-control	8	History of previous colic (OR=3.9, 95% CI=2.6-5.9, p<0.001)

		Cohen and Peloso, (1996)	Case-control	8	*History of abdominal surgery (OR=3.08, 95% CI=1.86-5.10, p<0.0001)
		Cohen *et al.* (1995)	Case-control	8	History of previous colic (OR=5.72, 95% CI=4.70-6.96, p<0.001) History of abdominal surgery for colic (OR=5.31, 95% CI=2.56-10.99, p<0.001)
		Reeves *et al.*, (1996b)	Case-control	8	Previous history of colic + non-owner carer (OR=4.9, 95% CI=2.4-9.9)
Parasites	1	Leblond *et al.*, (2002)	Case-control	7	Parasitism (OR=1.91, 95% CI=1.33-2.75, p<0.001)
Vaccines	1	Tinker *et al.*, (1997b)	Cohort	8	Potomac horse fever (PHF) vaccine during study (1 year) (OR=2.0, 95% CI=1.2-3.6, p=0.005)
Dental problems	1	Scantlebury *et al.* (2011)	Cohort	8	Known dental problem (OR=5.1, 95% CI=1.3-21.0, p=0.02)
Environmental factors Season	2	Cohen *et al.*, (1999b)	Case-control	8	Change in weather within 3 days (OR=3.2, 95% CI=2.0-4.9, p<0.001)
		Archer *et al.* (2006b)	Case-control	7	Both 6 and 12 month cyclical patterns for all colics

*Results extracted from Cohen *et al.,* 1996 are solely from multiple logistic regression analysis of risk factors associated with a history of colic and not from analysis of risk factors for a history of chronic intermittent colic. OR = Odds Ratio, CI = Confidence Interval

2.4 Discussion

Published research has explored a variety of factors potentially associated with increased risk of abdominal pain in the horse, but consolidating these studies was complicated by the many different causes and types of colic. There was significant variation in study design and clinical populations. This meant that consolidating evidence across different studies was challenging, and is not currently feasible for the specific causes of colic. The key outcomes of this study were to summarise and categorise the different types of studies, and to highlight the strengths and weaknesses of the current evidence.

2.4.1 Systematic review methodology

The PRISMA statement reporting guideline is the most commonly cited framework for systematic reviews., but focuses on evaluating RCTs. There are relatively few systematic reviews of risk factors in both human and veterinary medicine,,and only one published systematic review of risk factors in equine medicine (Wylie *et al.*, 2012). There is no universally accepted methodology for systematic reviews of risk factors, and critical appraisal tools can vary considerably (Katrak *et al.*, 2004). The systematic review of risk factors by Wylie *et al.* (2012) used a numerically scored critical appraisal tool, designed specifically for that review. There is debate on the use of numerical scoring systems, and a weighted scheme approach is commonly adopted critical appraisal tools, including those available from CASP (Critical Appraisal Skills

Programme), JBI-SUMARI (Joanna Briggs Institute – System for the Unified Management, Assessment and Review of Information) and the Cochrane Collaboration (Whiting *et al.*, 2006). This reduces the influence of researcher bias, and allows the reader to make decisions on the quality of the study, the appropriateness of the design and the relative application of the findings (Gough, 2007).

There is a lack of multi-centre international veterinary research studies, and therefore the highest quality publications do not currently exist. There is currently no consensus on which publications should be evaluated in systematic reviews (Katrak *et al.*, 2004; Gough, 2007). A prospective cohort study is considered the most appropriate study design (other than systematic reviews and meta-analyses) to answer an aetiological research question (Merlin *et al.*, 2009). In this systematic review, all cohort, case-control and cross-sectional studies which met inclusion criteria were appraised. The cohort and case-control studies with the least susceptibility to bias were then selected to summarise the current evidence, similar to other systematic reviews of risk factors (Beauvais *et al.*, 2012; Wylie *et al.*, 2012; Kwok *et al.*, 2013). Case series and cross-sectional study designs are lower levels of evidence for risk factor research (Mann, 2003; Merlin *et al.*, 2009) and were not included in the final analysis. .

2.4.2 Limitations of the evidence

The main limitation of the evidence from this research and much of the evidence-based medicine in the veterinary context is that it is based on less-than ideal levels of evidence. Continued research using well-designed studies to improve the evidence-base is important to support effective decision-making in veterinary practice. If 'gold standard' evidence is lacking, the alternative to make use of other forms of evidence is preferable to no evidence at all. There must however be an awareness and acceptance that there is likely to be flaws and limitations to this level of evidence. The distinction between best, good and poor evidence is generally lower than that of the medical research, and this is currently the reality of EVM

Susceptibility to bias was identified in most of the publications, using the JBI-MAStARI critical appraisal tool. Many studies were not representative of the general population, both in terms of their geographical location and the type of veterinary practices where the data was collected. There was a relatively high proportion of studies based within referral hospitals (9/24 'general' colic studies, 11/23 'specific' disease studies, and 14/17 case series), which may limit the transferability of findings to the wider horse population. The majority of studies were based in the US (11/24 'general' colic studies, and 11/23 'specific' disease studies), and there is a need for multicentre international studies to determine which risk factors are influenced by geographical location. A number of publications failed to identify and

discuss the potential confounders of results, and advances in information and resources on evidence-based medicine should assist authors with critical review of study methodology. In addition, case-control studies (which contributed 14/24 included publications) commonly used flawed methods to select cases and controls. Use of methodology to specifically investigate risk factors, and based in a representative population, will alleviate some of the susceptibility to bias that was identified in this systematic review (Shamliyan *et al.*, 2010; Vandeweerd *et al.*, 2012a).

Another challenge in conducting systematic reviews is summarising evidence from studies that vary in their methodology and the populations that were assessed. In this systematic review, agreement between three or more publications including one cohort study was considered to be good evidentiary support. There was agreement between at least two publications for most of the potential risk factors when considered as broader categories, such as age, breed and history of disease. There was much inconsistency and less agreement for associations within each category (for example Thoroughbred breed within the Breed category, coastal grass hay within the Feed category or a recent change in weather within the Season category). Future research which investigates the same categories and risk factors is needed to develop a stronger evidence base for many risk factors (Furlan *et al.*, 2009).

The reference categories that were used for analysis were often inconsistent across different publications. One example was the reference groups used for Breed category across the ten final publications; Arab horses were at higher risk in three publications (Cohen and Peloso, 1996; Reeves *et al.*, 1996; Cohen *et al.*, 1999) but each study used a different reference category. Consistency across research is essential to demonstrate a valid risk factor. Variation in reference ranges, definitions and categories limits the consolidation of findings in a comparative review. Research studies that vary these aspects of methodology, without giving any justification for alterations, further confuse the evidence base.

Different methodologies between studies also led to inconsistencies and weak agreement between publications, and contributed to results that could not be extrapolated and comparably applied to the population. For example, both Tinker *et al.* (1997b) and Reeves *et al.* (1996) identified feeding whole grain as a potential risk factor; however Reeves *et al.* (1996) did not describe what type of whole grain was investigated and Tinker *et al.* (1997b) specified whole grain corn as the factor of interest. Also, the length of time measured between management change (for example, change of diet) and occurrence of abdominal pain/admission to referral hospital varied between two weeks (Cohen *et al.*, 1995) and one year (Tinker *et al.*, 1997b).

There is likely to be an interaction between many risk factors, which may confound or influence results of non-standardised studies. This

highlights the importance of multivariable logistic analysis, and also the effect of the researcher in identifying biologically plausible interactions when developing the final model. Most publications failed to acknowledge confounders or factors introducing bias.

and Reeves *et al.* (1996); Scantlebury *et al.* (2011) were the only studies to incorporate specific owner factors into their investigation, and yet this is a complex and influential aspect of the care of the horse. Recent research has highlighted the variation in owner attitudes and approaches to colic and horse management (Allison *et al.*, 2011; Scantlebury *et al.*, 2014). Factors such as the owner's experience, the number of horses they care for, and their attitudes towards preventative health care, such as anthelmintic use and dental care, should be considered in future research on risk factors.

2.4.3 Evidence for risk factors for abdominal pain

There was sufficient evidence to support increasing age as a risk factor for abdominal pain, but the variations in study design mean that a specific age category cannot yet be identified. The evidence for Arab breed also supports this conclusion, Based on the consistent agreement, and other findings of feed-related risk factors, it is likely that feed management is also an overarching category which is associated with colic.

The evidence was furthermore sufficient to suggest acceptable evidentiary support for a previous history of colic as a risk factor. More

cohort studies are needed to strengthen the level of evidence for this risk factor.

Despite the issues and limitations, this systematic review identified similar findings across different studies for age, breed, recent change in management and a previous history of abdominal pain.

2.4.4 Recommendations for further work

It is clear from the results of this systematic review that a detailed multivariable analysis of all risk factors would be challenging, and results of risk factor studies must be considered in a broad context of the methodological design and subject variability. However, if studies were designed using a standardised method with consideration of previous research, levels of bias could be minimised. Additionally, standardised methodology would permit repetition of studies and therefore validation of potential risk factors with similar reference ranges/categories.

Case-control studies are not the ideal study design to investigate risk factors, and the high level of convenience sampling in the studies in this systematic review may bias the results (Mann, 2003). There were only three cohort studies in the final ten publications. Two out of these three are dated (Tinker *et al.*, 1997b; Traub-Dargatz *et al.*, 2001), and one is focused on recurrent colic (Scantlebury *et al.*, 2011). Three cohort studies with different methodologies is not adequate to investigate a complex and multi-factorial problem such as colic. There is a need for

less case-control and more prospective cohort studies to raise the level of evidence and improve the overall evidence base.

The issues with bias from study populations have been described earlier, and this is an important area that needs addressing. There is a need for more collaboration to develop multi-centre prospective cohort studies. There have been successful collaborations between two or more equine practices in different counties (Tinker *et al.*, 1997a) and continents (Archer *et al.*, 2011; Borchers *et al.*, 2012; Blikslager and Mair, 2014), and the development of online tools for recording and exchanging data and information makes this more achievable. Key aspects going forward will be the online publication of methodology and data to assist other researchers, and the use of suitable keywords to allow effective electronic searches (Kabirzadeh *et al.*, 2013). A standardised set of keywords to index different types of study would make searching for articles easier for researchers and practitioners. Retrospective tagging of keywords to dated publications would bring all the research together and ensure it is indexed into the correct category (Névéol *et al.*, 2010).

Key recommendations of further work include:

1. Development of a validated reporting guideline for risk factor studies in veterinary medicine to enable standardised methodology to be utilised by researchers.
2. Repetition of studies using similar reference ranges and categories to improve levels of evidence: alterations in

methodology should be justified and have a rationale basis (e.g. based on new or emerging evidence, or improvements in study design).

3. Establishment of international, multi-centre, prospective cohort studies investigating risk factors for abdominal pain in the horse that are complimentary with research already conducted.
4. Development of agreed veterinary research keywords to facilitate online literature searching, using the model of the MeSH (Medical Subject Heading) thesaurus (Majdoubi *et al.*, 2009).

2.5 Conclusion

Despite the plethora of available literature, there are still significant gaps in the current evidence, and future research needs to recognise the strengths and weaknesses of previous work in order to improve and develop the evidence on risk factors for colic.

L. Curtis was the main reviewer for this phase of work, and carried out every step of the systematic review including the planning, execution and alterations to methodology. S. Freeman independently read and quality assessed all the publications from abstract to full text stage as part of the evidence assessment methodology. J. Burford acted as third reviewer when. S. Freeman, G.C.W. England and J. Burford acted as supervisors for this phase of work. Advice on methodology and study design was also received from R. Dean.

CHAPTER THREE: Tests used in the diagnostic approach of abdominal pain in the horse – A systematic review

This chapter meets the following objective: To appraise and consolidate the evidence on the diagnosis of equine abdominal pain through a systematic review of the existing literature.

3.1 Introduction

Abdominal pain (colic) is common in the horse and most cases are mild and do not require referral for specialist treatment (Archer, 2004). It is important however, for the attending veterinary practitioner to differentiate between a case that will resolve spontaneously with minor treatment, and a case that requires significant intervention that may include surgery to improve outcome and welfare (Ramey, 2008). Time to initiate treatment is an integral factor for an optimal result for the patient (fundamentally), but also for the owner. Proudman *et al.* (2005) showed that progression or worsening of the clinical case could be monitored by changes in some cardiovascular parameters (increasing packed cell volume and decreasing total plasma protein) over time, and that these were statistically associated with a greater risk of death. The initial examination of the horse, including the clinical examination and various diagnostic tests is an important part of decision-making, but there has been minimal evaluation of the evidence base to support the use of different diagnostic approaches. There are several textbooks and expert opinion articles which discuss the diagnostic approach to abdominal pain in the horse; few of these are supported with evidence and some are dated (Greatorex, 1972; Pinsent, 1990; Taylor *et al.*, 1997). There are a number of studies evaluating different diagnostic approaches to abdominal pain, some have identified important physical parameters and others have evaluated tests which may differentiate between medical and surgical cases (Mair and Hillyer, 1997; Freden *et al.*, 1998; Abutarbush, 2006; Goncalves *et al.*, 2006); there appears to

be a wide variety of approaches with limited consistency with, or evaluation of, previous literature. Many of these studies do not truly evaluate diagnostic test accuracy, and instead assess efficacy or test 'usefulness' instead. There is a need for a systematic review of research on the diagnostic approach to abdominal pain in the horse to help veterinary practitioner decision-making. A review would appreciate and confirm the evidence for diagnostic tests, especially those that are used clinically for differentiation of cases requiring surgical intervention (Ramey, 2008). For the purpose of this systematic review the term 'diagnostic test' follows the definition set by Bossuyt *et al.* (2003):

"Any method for obtaining additional information on a patient's health status. This includes laboratory tests, imaging tests, function tests, pathology, history and physical examination."

The research question for this systematic review was: Which diagnostic tests are effective at differentiating horses with abdominal pain that require surgical intervention from those that do not, using a reference standard of surgery or necropsy for surgical cases?

A systematic review was conducted with the following objectives:

- To identify publications relating to diagnostic tests used for abdominal pain in the horse, through a systematic search of databases.

- To describe the methodological features of literature relating to diagnostic tests used to differentiate horses with abdominal pain that require surgical intervention.

- To evaluate the quality of published literature relating to diagnostic tests used to differentiate horses with abdominal pain that require surgical intervention.

- To summarise the best evidence on diagnostic tests used to differentiate horses with abdominal pain that require surgical intervention.

3.2 Methodology

This project was approved by the Ethics Committee, School of Veterinary Medicine and Science, University of Nottingham. There were three phases to the systematic review, linked to the chapter objectives.

3.2.1 Identification of publications relating to diagnostic tests used for abdominal pain in the horse.

The primary literature search was conducted in CAB Abstracts (1910-2014), WEB of Science (1950-2014) and MEDLINE (1946-2014) on 24/03/2014 using the following terms: (horses OR horse OR equine OR equines OR equus OR equidae OR equids OR equid) AND colic (which included abdominal pain). Diagnostic search terms were not used because it was evident following a trial search and subsequent cross-

referencing of findings that many publications were not adequately indexed and there was a risk of incomplete search results.

The results of each search were downloaded into bibliological software (EndNote X6, Thomson Reuters), duplicates were searched for by author, title and reference and deleted within EndNote after each database search and extraction was completed. All remaining titles within the EndNote library were screened for terms indicating diagnosis, diagnostic approach or diagnostic testing of abdominal pain/colic or its associated diseases. Following screening, relevant titles were transferred to a separate group entitled ‘Diagnosis’, and any ambiguous titles were retained for further review at the next stage (review of abstracts).

Abstracts were individually assessed for eligibility by two reviewers (TC and LC) using inclusion/exclusion criteria (Table 11). Appropriate study design was one of the criteria for inclusion; studies of diagnostic test accuracy are the ‘gold standard’ study design in this systematic review. There were no available studies of this design for equine abdominal pain, therefore acceptable study designs were considered as cross-sectional, randomised controlled trials, case-control, cohort studies and case series for an investigation of diagnostic test and/or physical parameter efficacy. All eligible publications and any ambiguous abstracts were taken forward to the next stage of review; critical appraisal of the full publication.

Table 11. Inclusion and exclusion criteria for a systematic review of clinical parameters and tests used in the diagnosis of equine abdominal pain.

Inclusion	**Exclusion**
Gastrointestinal causes of abdominal pain	Non-gastrointestinal causes of abdominal pain
Studies with diagnosis as the primary focus	Studies which only evalulated prognosis
Studies with >3 cases	Studies with ≤ 3 cases
All types of *Equus caballus*	Donkeys
All types of abdominal pain	Articles not in English
Conference proceedings presented as research abstracts	Narrative reviews (including those in conference proceedings)
Peer and non-peer reviewed	Textbook chapters
*Full text available	

*A study was excluded if full text could not be obtained from any of the University of Nottingham libraries or e-libraries, through University of Nottingham journal subscriptions, during one of three visits to the British Library, or from free online Open Access.

3.2.2 Critical appraisal of publications relating to diagnostic tests used to differentiate horses with abdominal pain that require surgical intervention

The methodology of eligible publications identified by the primary search and inclusion terms were reviewed. Those publications which

used surgery or necropsy as a reference standard for surgical cases, and response to medical management, surgery or necropsy for non-surgical cases were extracted. The extracted publications were divided into two sub-groups designated ‘Surgical General Colic’ and ‘Surgical Specific Colic’ (Table 12).

Table 12. Definitions for two sub-groups for publications relating to diagnostic tests for abdominal pain in the horse.

‘Surgical General Colic’	**‘Surgical Specific Colic’**
Publications related to a test or physical parameter for the diagnosis of abdominal pain across a range of different diseases of colic, requiring surgical intervention.	Publications related to a test or physical parameter for the diagnosis of specific disease causing signs of abdominal pain, requiring surgical intervention. For example: grass sickness and enterolithiasis

Critical appraisal of the publications was performed in two stages. Initially, the methodological features of all publications, including those categorised as ‘Surgical General Colic’ and ‘Surgical Specific Colic’, were described. The second step was a quality appraisal and assessment of bias of publications within the sub-group ‘Surgical General Colic’.

3.2.2a Methodological features of the published research, study design and study population

After categorisation into either ‘Surgical General Colic’ or ‘Surgical Specific Colic’, each publication meeting the inclusion criteria was sub-categorised according to the diagnostic test or physical parameter assessed (for example blood, peritoneal fluid) and the methodological features were then described. The description included the study design, the reference standard used, study population (e.g. referral hospital or primary practice), the total number of horses in the study, the number of cases/samples that were assessed, and the diagnostic tests or physical parameters that were measured. Whilst the process was performed for publications which met the criteria for ‘Surgical Specific Colic’, this group of publications were not taken forward to the quality appraisal stage of systematic review. Two reviewers (LC and TC) discussed and agreed the final list of publications with the support of a third reviewer (SF).

3.2.2b Quality appraisal of the sub-group of ‘Surgical General Colic’ group publications

The included ‘Surgical General Colic’ publications were independently assessed by two reviewers (LC and TC) for methodological validity and susceptibility to bias using the QUADAS appraisal tool for the quality assessment of studies of diagnostic accuracy (Whiting *et al.*, 2003) (Table 13). The QUADAS tool was adapted by the addition of five assessment criteria considered important in studies of diagnostic tests,

as stated within the STARD Statement (standards for the reporting of diagnostic accuracy studies) (Bossuyt *et al.*, 2003). Assessment criteria added to the QUADAS tool were intended to ensure publications were assessed for their applicability to general practice. Additional criteria were also designed to check if the publications examined the efficacy and usefulness of the tests using appropriate multivariable statistical analysis. Any lack of agreement between the reviewers was resolved through discussion with a third reviewer (SF).

For each of the 19 QUADAS appraisal criteria, publications were rated as either 'Yes', 'No' or 'Unclear'. The number of 'Yes' ratings for each publication were summed as a measure of individual study methodological quality and an indication of susceptibility to bias between publications. QUADAS criteria attainment (total number of 'Yes' ratings for each criterion) were summed as a measure of methodological quality across all publications.

QUADAS quality assessment outcomes, including total number of 'Yes' ratings and criteria attainment were recorded in a table, ranked primarily according to study design (cross-sectional followed by randomised controlled trials, case-control, cohort and finally case series) and secondarily by the sum of 'Yes' ratings for each study. Publications which had total summed scores in the top quartile of all the publications (summed quality criteria attainment of 14 or more 'Yes' ratings) were considered to demonstrate the highest level of quality and the best evidence. The remaining publications were judged by the reviewers to

have a high level of bias and were removed. In the absence of validated protocol, the target rating (14) was subjectively chosen using guidance from existing publications (Treadwell *et al.*, 2011; Beauvais *et al.*, 2012; Kwok *et al.*, 2013). The findings of this top quartile of publications were then extracted and summarised. No statistical tests for heterogeneity or quantitative analysis were performed, as there was marked variation between the publication methodology and assessments.

An assessment of how individual publications were rated across different QUADAS quality appraisal criteria was presented to identify the best evidence. Also, how the different publications rated for each individual appraisal criteria was assessed to identify methodological strengths and weaknesses across the whole body of evidence. Recommendations were made for future research.

Table 13. Methodological quality assessment tool used in a systematic review of diagnostic tests used for abdominal pain in the horse, using an adapted QUADAS tool (Whiting *et al.*, 2003)*.

	Criterion	**Yes**	**No**	**Unclear**
1	**Was the spectrum of patients representative of the patients who will receive the test in practice?**			
2	**Were selection criteria clearly described?**			
3	**Is the reference standard likely to correctly classify the target condition?**			
4	**Is the time period between reference standard and index test short enough to be reasonable sure that the target condition did not change between the two tests?**			
5	**Did the whole sample or a random selection of the sample, receive verification using a reference standard of diagnosis?**			
6	**Did patients receive the same reference standard regardless of the index result?**			
7	**Was the reference standard independent of the index test (i.e. the index test did not form part of the reference standard)?**			
8	**Was the execution of the index test described in sufficient detail to permit replication of the test?**			
9	**Was the execution of the reference standard described in sufficient detail to permit its replication?**			
10	**Were the index test results interpreted without knowledge of the results of the reference standard?**			
11	**Were the reference standard results interpreted without knowledge of the results of the index test?**			
12	**Were the same clinical data available when test results were interpreted as would be available when test is used in practice**			
13	**Were uninterpretable/intermediate test results reported?**			
14	**Were withdrawals from the study explained?**			
15	Were sensitivity and specificity calculations carried out?			
16	Are reference ranges for the index test discussed and were they pre-specified?			
17	Were an appropriate number of colic cases studied?			
18	Was statistical analysis appropriate and clearly described?			
19	Could the methodology be feasibly repeated in a field environment?			

*Criteria 1-14 (bold) directly from QUADAS, criteria 15-19 (non-bold) added by author (LC). Index test refers to the test under evaluation

3.2.3 Summary of the best evidence for diagnostic tests for the differentiation of cases of abdominal pain in the horse requiring surgical intervention.

The best quality publications within the 'Surgical General Colic' group were summarised to identify the best available evidence. The threshold for this was publications which attained 14 or more 'Yes' ratings, and therefore demonstrated a relative low susceptibility to bias and high methodological quality.

3.3 Results

3.3.1 Identification of publications relating to diagnostic tests used for abdominal pain in the horse.

The initial search identified 5508 publications containing the search terms across the three databases. After screening of the titles and removing duplicates, and any publications immediately recognised as non-diagnostic, a total of 190 publications remained for the abstract analysis stage. Of these, the inclusion criteria were met by 46 publications. The required reference standard of surgery or necropsy for surgical cases was utilised by 35 publications; 30 of these were categorised into the 'Surgical General Colic' sub-group (publications related to a test or physical parameter for the diagnosis of clinical signs of abdominal pain across a range of different diseases of colic, requiring surgical intervention) and five publications were categorised into the

‘Surgical Specific Colic’ sub-group (publications related to a test or physical parameter for the diagnosis of specific disease causing signs of abdominal pain, requiring surgical intervention) (Figure 8).

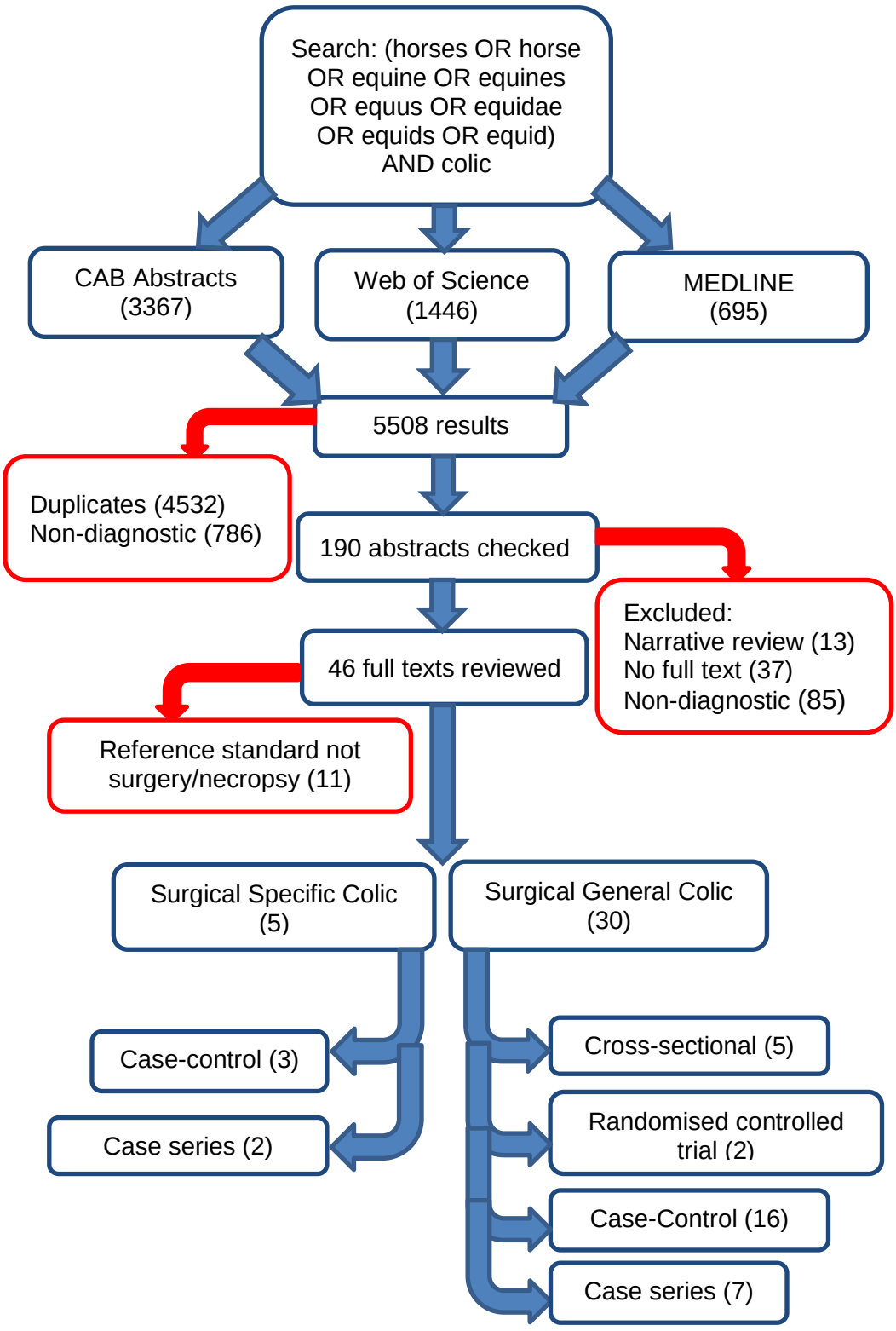


Figure 8. Literature search flow chart for a systematic review of tests used in the diagnosis of cases of equine abdominal pain requiring surgical intervention.

3.3.2 Critical appraisal of publications relating to diagnostic tests used to differentiate horses with abdominal pain that require surgical intervention

There were 35 eligible publications meeting the inclusion/exclusion criteria; 30 publications in the 'Surgical General Colic' sub-group, and 5 publications in the 'Surgical Specific Colic' sub-group. In the first step of critical appraisal, the methodological features of all 35 publications were assessed. In the second step of critical appraisal, the 30 publications in the 'Surgical General Colic' sub-group were appraised for methodological quality and susceptibility to bias.

3.3.2a Methodological features of the current published research, study design and study population

The methodological features of all 35 publications (both 'Surgical General Colic' and 'Surgical Specific Colic' groups) can be found in Table 14. The 'Surgical General Colic' group consisted of two publications reporting on general and blood parameters, and another on urine parameters. Blood parameters alone were investigated by nine publications, and blood and peritoneal fluid parameters were investigated in ten publications. Peritoneal fluid parameters alone were investigated by six publications. Two publications in the 'Surgical Specific Colic' group reported on radiographic parameters, one on ileal biopsy and two on blood parameters. A range of different diagnostic tests were investigated, with the majority of tests only being evaluated

in single publications. There were three publications evaluating the use of alkaline phosphatase concentrations in diagnosing surgical colic. There were also two publications evaluating the value of blood and/or peritoneal concentrations of lactate, investigating blood concentrations of serum amyloid, three publications on blood and/or peritoneal fluid tumour necrosis factors and two publications on blood or peritoneal fluid plasma D dimer levels.

The main study designs were case-control and case series followed by cohort studies and randomised controlled trials.. There were no studies used suitable methodology for evaluating diagnostic test accuracy, the quality of the current evidence was insufficient to enable further data extraction and consolidation of evidence. None of the publications replicated a previous study. Thirty-two out of 35 publications were conducted with referral hospital populations, and the source of the study population was unclear in 3/35 publications (Datt and Usenik, 1975; Milne *et al.*, 1991; Waggett *et al.*, 2010).

Table 14. Methodological features of 35 publications which met the inclusion criteria in a systematic review of tests used in the diagnosis of abdominal pain in the differentiation of cases requiring surgical intervention.

Author	Study design	Reference standard	Study population	*Total number horses	Number of colic cases	Description of diagnostic test/ parameter provided in publication
Category: 'Surgical General Colic'						
Sub-category: General parameters and urine						
Parry *et al.* (1983)	XS	RMM/S/N	Australia. 1 University referral hospital	100	80 colic (39 medical, 41 surgical)	Physical parameters and various biochemical tests
Datt and Usenik (1975)	RCT	Induced Lesions	No country stated. Clinically healthy ponies approx. 2-12 years old	18	18 induced colic	Changes in clinical parameters and blood parameters after iatrogenic obstruction of bowel
Noschka *et al.* (2011)	CC	RMM/S/N	USA. 1 University referral hospital. Controls from local horse show	85	43 colic (21 medical, 22 surgical)	Urine F2-isoprostane metabolite as a predictor for requirement of surgery
Sub-category: Blood						
Kaya and Iben (2009)	XS	RMM/S/N	Austria. 1 University referral hospital	1546	249 colic	Serum alkaline phosphatase activity, serum bile acids and specific bacteria in faeces
Cesarini *et al.* (2010)	CC	RMM/S/N	Spain. 1 Referral teaching hospital. Controls from local riding school	523	493 colic (229 medical, 74 surgical, 74 inflammatory, 33 ischemic without resection, 51 ischemic with resection, 32 peritonitis)	Plasma D-Dimer concentration
Forbes *et al.* (2011)	CC	RMM/S/N	Australia. 1 University referral hospital	39	29 colic (9 inflammatory, 11 strangulating, 9 non-strangulating)	Activin A concentration
Grulke *et al.* (2002)	CC	Exploratory Laparotomy/ Necropsy	Belgium. 1 University referral hospital. Healthy controls, unknown source	75	37 surgical	Plasma trypsin levels

Gomaa *et al.* (2011)	CC	RMM/S/N	Germany. 1 University referral hospital. Healthy controls teaching hospital & riding school	107	77 colic (36 non-strangulating, 22 strangulating, 19 colon torsion)	Serum alcohol dehydrogenase activity in colic cases
Navarro *et al.* (2005)	CC	RMM/S/N	Spain. 1 Referral teaching hospital	115	115 colic (69 obstructive, 17 ischemic, 20 inflammatory, 9 diarrheic)	Acid-base and electrolyte imbalance
Weiss and Evanson (2003)	CC	RMM/S/N	USA. University referral hospital. Controls university teaching herd	60	30 colic	Activated neutrophils
Morris and Moore (1989)	CS	RMM/S/N	USA.1 University referral hospital	102	102 colic	Antibody titres to core lipopolysaccharides
Morris *et al.* (1991)	CS	RMM/S/N	USA. 1 University referral hospital	289	289 colic (57 inflammatory, 43 strangulating, 189 non-strangulating)	Serum tumor-necrosis-factor activity
Prasse *et al.* (1993)	CS	RMM/S/N	USA. 1 University referral hospital	233	233 colic (47 inflammatory, 26 strangulating, 160 non-strangulating)	Haemostasis analysis
Steckel and Smith (1992)	CS	RMM/S/N	USA. 1 University referral hospital	26	26 colic	Endotoxin detection
Sub-category: Blood and peritoneal fluid						
Nieto *et al.* (2005)	XS	RMM/S/N	USA. 1 University referral hospital	99	86 colic (33 medical, 53 surgical)	Intestinal fatty acid binding protein
Yamout *et al.* (2011)	XS	RMM/S/N	USA. 1 University referral hospital	96	90 colic	Peritoneal and plasma D-lactate concentration
Arden and Stick (1988)	CC	RMM/S/N	USA. 1 University referral hospital	98	89 colic (37 medical, 26 laparotomy no resection, 26 laparotomy extensive lesions)	Serum and peritoneal fluid phosphate concentration

Arguelles *et al.* (2010)	CC	RMM/S/N	Spain. 1 University teaching hospital	86	78 colic (28 obstructive, 20 enteritis, 22 ischaemic, 8 peritonitis)	Serum and peritoneal transforming growth factor beta
Barton and Collatos (1999)	CC	RMM/S/N	USA. 1 University referral hospital	175	155 colic (33 inflammatory, 25 strangulating, 55 non-strangulating non-inflammatory, 34 open, 8 ruptured viscous)	Tumor necrosis factor activity, Interleukin-6 and endotoxin concentrations
Delesalle *et al.* (2005)	CC	RMM/S/N	Belgium. 1 University referral hospital. Healthy controls from faculty herd	126	106 colic (66 strangulating, 40 non-strangulating	Serotonin (5-HT) concentration
Grulke *et al.* (2008)	CC	RMM/S/N	Belgium. 1 University referral hospital. Healthy controls from faculty herd	141	103 colic (38 non-strangulating LI, 21 strangulating LI, 32 strangulating SI, 12 inflammatory bowel disorders)	Myeloperoxidase assay
Latson *et al.* (2005)	CC	RMM/S/N	USA. 1 University referral hospital	209	189 colic	Peritoneal fluid lactate as a marker of ischaemia
May *et al.* (1992)	CC	Exploratory Laparotomy	UK. 1 University referral hospital	20	14 surgical	Tumour necrosis factor
Saulez *et al.* (2004)	CS	RMM/S/N	USA. 1 University referral hospital	126	126 colic (65 medical, 61 surgical)	Alkaline phosphatase activity
Sub-category: Peritoneal fluid						
Froscher and Nagode (1981)	XS	RMM/S/N	USA. 1 University referral hospital	60	50 colic	Alkaline phosphatase activity
Adams *et al.* (1980)	RCT	Induced Lesions	USA. 1 University referral hospital	9	6 induced colic	Peritoneal fluid cytology
Delgado *et al.* (2009)	CC	RMM/S/N	Spain. 1 University referral hospital	236	221 colic (68 obstructive, 45 enteritis, 44 ischaemic, 38 peritonitis, 26 mixed)	Peritoneal D-Dimer concentration

Weimann *et al.* (2002)	CC	RMM/S/N	Denmark, 1 University referral hospital	74	74 colic (39 medical, 35 surgical)	Spectrophotometric assessment of peritoneal fluid haemoglobin
Freden *et al.* (1998)	CS	RMM/S/N	USA. 1 University referral hospital	218	218 colic	Peritoneal fluid analysis
Swanwick and Wilkinson (1976)	CS/ Unclear	RMM/S/N	Australia. 1 University referral hospital	40	20 colic	Abdominal paracentesis
Category: 'Surgical Specific Colic'						
Sub-category: Radiography						
Maher *et al.* (2011)	CS	RMM/S/N	USA. 1 University referral hospital	142	142 colic; 3 reviewers	Computed radiographic measurements (enterolithiasis)
Yarbrough *et al.* (1994)	CS	RMM/S/N	USA.1 University referral hospital	141	141 colic; 3 reviewers	Radiographic evaluation (enterolithiasis)
Sub-category: Ileal biopsy						
Waggett *et al.* (2010)	CC	Histo-pathology	Source of samples unclear	60	50 colic (10 acute GS, 10 subacute GS,6 suspected neuroparalytic botulism, 24 non-GS)	Immunolabeling of ileal neurons for synaptophysin expression (grass sickness)
Sub-category: Blood						
Copas *et al.* (2013)	CC	Histo-pathology	UK. 1 University referral hospital, 1 equine referral hospital	93	58 colic (40 GS, 18 non-GS)	Serum amyloid A, plasma fibrinogen and activin A
Milne *et al.* (1991)	CC	Histo-pathology	Source of samples unclear	92	58 colic (16 colic, 17 acute GS, 16 subacute GS, 9 chronic GS)	Serum haptoglobin, orosomucoid, ceruloplasmin and α2-macroglobulin

* Total number of horses including colic and non-colic cases. XS=Cross-sectional, RCT= Randomised controlled trial, CC=Case-control, CS=Case series, RMM/S/N= Response to medical management/Surgery/Necropsy, LI= Large intestine, SI= Small intestine GS= Grass sickness

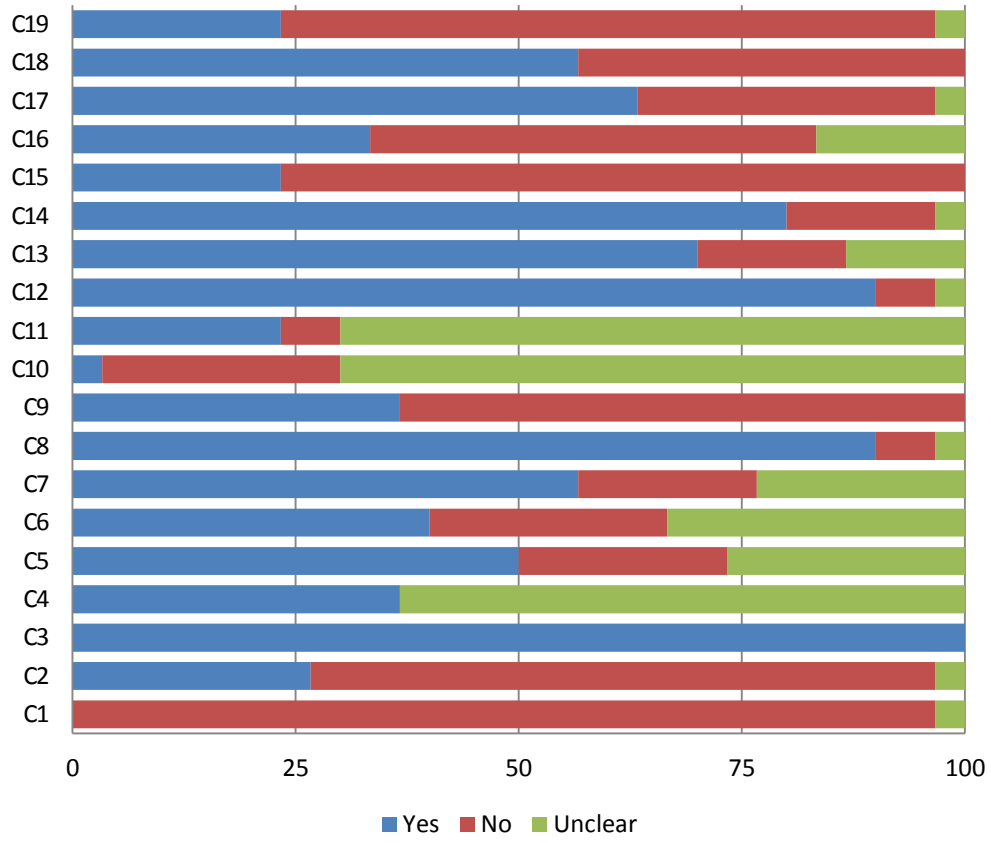
3.3.2b Quality appraisal of the sub-group of 'Surgical General Colic' group publications

There were 30 included publications in the 'Surgical General Colic' group which were quality assessed using the adapted QUADAS critical appraisal tool for diagnostic test evaluations. The number of 'Yes' ratings and the level of criteria attainment within and between publications is shown in Table 15 and Figure 9. The most poorly attained criteria were Criterion 1: 'Was the spectrum of patients representative of the patients who will receive the test in practice?' (0%), Criterion 11: 'Were the reference standard results interpreted without knowledge of the results of the index test?' (23.3%). Also, Criterion 10: 'Were the index test results interpreted without knowledge of the results of the reference standard?' (3.3%), Criterion 15: 'Were sensitivity and specificity calculations carried out?' (23.3%) and Criterion 19: 'Could the methodology be feasibly repeated in a field environment?' The criteria most consistently met were Criterion 8: 'Was the execution of index test described in sufficient detail to permit replication of the test?' (90%), Criterion 12: 'Were the same clinical data available when test results were interpreted as would be available when the test is used in practice?' (90%). Also Criterion 14: 'Were withdrawals from the study explained?' (80%). Criterion 3: 'Is the reference standard likely to correctly classify the target condition?' was attained by all of the publications due to them being selected based on this requirement.

Table 15. Methodological quality of 30 publications in a systematic review of clinical parameters and tests used in the diagnosis of general equine abdominal pain requiring surgical intervention.

Study	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	Yes total
Cross-sectional																				
Yamout 2011	N	Y	Y	?	Y	Y	Y	Y	N	N	?	Y	?	Y	Y	?	Y	Y	Y	12
Parry 1983	N	N	Y	Y	Y	Y	N	?	Y	N	N	Y	Y	Y	N	?	Y	N	Y	10
Nieto 2005	N	N	Y	?	?	?	?	Y	N	?	?	Y	Y	Y	Y	N	Y	Y	N	8
Kaya 2009	N	N	Y	?	?	?	?	Y	N	?	?	Y	Y	Y	N	N	Y	N	N	6
Froscher 1981	N	N	Y	?	?	?	?	Y	N	?	?	?	Y	Y	N	N	N	N	N	4
Randomised controlled trial																				
Datt 1975	?	N	Y	Y	Y	N	Y	Y	Y	N	N	Y	Y	Y	N	Y	N	N	N	10
Adams 1981	N	N	Y	?	N	N	Y	Y	Y	?	?	Y	Y	Y	N	N	N	N	N	8
Case-control																				
Latson 2005	N	Y	Y	Y	Y	Y	Y	Y	N	?	?	Y	Y	Y	N	N	Y	Y	Y	13
Weimann 2002	N	Y	Y	?	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	N	Y	Y	Y	13
Gomaa 2011	N	Y	Y	?	Y	Y	N	Y	Y	?	Y	Y	Y	Y	Y	N	Y	Y	N	13
Barton 1999	N	N	Y	Y	Y	N	?	Y	Y	?	?	Y	Y	Y	Y	Y	Y	Y	N	12
Arden 1988	N	Y	Y	?	N	N	Y	Y	N	Y	?	Y	Y	Y	Y	N	Y	Y	N	11
Navarro 2005	N	Y	Y	Y	Y	N	Y	Y	N	?	?	Y	Y	Y	N	N	Y	Y	N	11
Cesarini 2010	N	Y	Y	?	?	?	Y	Y	N	?	?	Y	Y	Y	N	Y	Y	Y	N	10
Delgado 2009	N	N	Y	Y	Y	?	N	Y	N	?	?	Y	Y	Y	N	Y	Y	Y	N	10
Grulke 2008	N	N	Y	?	Y	Y	N	Y	N	?	?	Y	Y	Y	N	Y	Y	Y	N	10
Arguelles 2010	N	Y	Y	?	?	?	N	Y	N	?	?	Y	Y	Y	N	Y	Y	Y	N	9
Delesalle 2007	N	N	Y	Y	N	Y	Y	Y	Y	?	?	Y	Y	Y	N	N	N	N	N	9
Grulke 2002	N	N	Y	?	N	Y	Y	Y	N	?	?	Y	Y	Y	N	Y	N	Y	N	9
Weiss 2003	N	N	Y	Y	Y	Y	Y	Y	Y	?	Y	Y	?	N	N	?	N	N	N	9
Noschka 2011	N	N	Y	Y	N	Y	Y	Y	N	?	?	Y	Y	Y	N	N	N	N	N	8
Forbes 2011	N	N	Y	?	N	N	Y	Y	N	?	?	Y	Y	Y	N	N	N	N	N	6
May 1992	N	N	Y	?	?	?	?	Y	N	?	?	Y	Y	Y	N	N	N	N	N	5
Case series																				
Prasse 1993	N	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	?	?	N	?	Y	N	N	10
Steckel 1992	N	?	Y	?	Y	Y	Y	Y	Y	N	Y	Y	?	N	N	?	?	Y	Y	10
Freden 1998	N	N	Y	?	N	?	?	N	N	?	?	Y	Y	Y	Y	Y	Y	Y	Y	9
Morris 1991	N	N	Y	?	?	?	Y	Y	N	?	?	Y	Y	Y	N	N	Y	Y	N	8
Morris 1989	N	N	Y	?	?	?	?	Y	N	?	?	Y	Y	Y	N	N	Y	Y	N	7
Saulez 2004	N	N	Y	Y	Y	N	Y	N	Y	N	Y	N	N	N	N	?	Y	N	?	7
Swanwick 1976	N	N	Y	?	Y	N	N	Y	N	N	Y	N	N	N	N	Y	N	N	Y	6
% of criterion attainment	0.0	26.7	100.0	36.7	50.0	40.0	56.7	90.0	36.7	3.3	23.3	90.0	76.7	80.0	23.3	30.0	63.3	56.7	23.3	

C1: Was the spectrum of patients representative of the patients who will receive the test in practice? C2: Were selection criteria clearly described? C3: Is the reference standard likely to correctly classify the target condition? C4: Is the time period between reference standard and index test short enough to be reasonable sure that the target condition did not change between two tests? C5: Did the whole sample or a random selection of the sample, receive verification using a reference standard of diagnosis? C6: Did patients receive the same reference standard regardless of the index result? C7: Was the reference standard independent of the index test? C8: Was the execution of the index test described in sufficient detail to permit replication of the test? C9: Was the execution of the reference standard described in sufficient detail to permit its replication? C10: Were the index test results interpreted without knowledge of the results of the reference standard? C11: Were the reference standard results interpreted without knowledge of the results of the index test? C12: Were the same clinical data available when test results were interpreted as would be available when test is used in practice? C13: Were uninterpretable/intermediate test results reported? C14: Were withdrawals from the study explained? C15: Were sensitivity and specificity calculations carried out? C16: Are reference ranges for the index test discussed and were they pre-specified? C17: Were an appropriate number of colic cases studied? C18: Was statistical analysis appropriate and clearly described? C19: Could the methodology be feasibly repeated in a field environment? Y = Yes, N = No,? = Unclear



C1: Was the spectrum of patients representative of the patients who will receive the test in practice? C2: Were selection criteria clearly described? C3: Is the reference standard likely to correctly classify the target condition? C4: Is the time period between reference standard and index test short enough to be reasonable sure that the target condition did not change between two tests? C5: Did the whole sample or a random selection of the sample, receive verification using a reference standard of diagnosis? C6: Did patients receive the same reference standard regardless of the index result? C7: Was the reference standard independent of the index test? C8: Was the execution of the index test described in sufficient detail to permit replication of the test? C9: Was the execution of the reference standard described in sufficient detail to permit its replication? C10: Were the index test results interpreted without knowledge of the results of the reference standard? C11: Were the reference standard results interpreted without knowledge of the results of the index test? C12: Were the same clinical data available when test results were interpreted as would be available when test is used in practice? C13: Were uninterpretable/ intermediate test results reported? C14: Were withdrawals from the study explained? C15: Were sensitivity and specificity calculations carried out? C16: Are reference ranges for the index test discussed and were they pre-specified? C17: Were an appropriate number of colic cases studied? C18: Was statistical analysis appropriate and clearly described? C19: Could the methodology be feasibly repeated in a field environment?

Figure 9. Combined quality assessment results for 30 publications in a systematic review of clinical parameters and tests used in the diagnosis of equine abdominal pain requiring surgical intervention.

3.2.3 Summary of the best evidence for diagnostic tests for the differentiation of cases of abdominal pain in the horse requiring surgical intervention.

Summary of the best available evidence within the 'Surgical General Colic' group was intended for publications which attained 14 or more 'Yes' ratings and therefore were in the top quartile for methodological quality and validity. The highest level of criteria attainment per study (number of 'Yes' ratings) was 13 and so none of the included studies attained an adequate overall quality assessment criteria score, and therefore further data extraction and summary was not performed.

3.4 Discussion

This was the first systematic review conducted which has identified, appraised and consolidated the evidence on diagnostic tests used in the diagnosis of equine abdominal pain. The methodological features of a total of 30 publications relating to a range of different diseases ('Surgical General Colic' group), and five publications relating to specific diseases causing signs of abdominal pain, requiring surgical intervention ('Surgical Specific Colic' group) were reviewed. The 30 publications in the 'Surgical General Colic' group were quality assessed using an adaptation of the QUADAS critical appraisal tool.

This systematic review demonstrated that no studies used suitable methodology for evaluating diagnostic test accuracy, the quality of the current evidence was insufficient to enable further data extraction and

consolidation of evidence. Despite these findings, this review provides an important and significant contribution to scientific knowledge by providing in a clear, accessible format which can be easily interpreted by veterinary practitioners and researchers a summary of the current literature, and identifying the main areas of weaknesses in study methodology. Furthermore, review of these aspects enables the development of recommendations for study design and methodology for future research. The assessment of methodological features of publications describing diagnostic tests for surgical colic has not been previously documented in detail. In this work, gaps in evidence have been identified along with deficiencies in the existing research. The evidence on diagnostic tests has been shown to be varied, both in terms of the quality of evidence and the diagnostic tests that have been studies. There is no crossover between studies describing similar parameters, and some of the most commonly used aspects of diagnostic approach, such as measurement of heart rate and conducting a rectal examination (Archer, 2004; Southwood, 2012) have limited or no good quality evidentiary support. In fact in this systematic review only two publications addressed heart rate (Datt and Usenik, 1975; Parry *et al.*, 1983) and no publication investigated rectal examination. Instead, most of the research has focused on referral hospital and laboratory-based tests, and when publications investigated the same parameters, they measured them in different ways so results could not be combined. An example is that there were three publications on alkaline phosphatase; measuring blood or peritoneal

fluid, or a combination of both (Froscher and Nagode, 1981; Saulez *et al.*, 2004; Kaya and Iben, 2009). Researchers are often reluctant to repeat previous research, and there is potential publication bias against replication studies (Neuliep and Crandall, 1993). This attitude must be overcome in order to build a reasonable body of evidence based on validation through several comparable publications (Monach, 2012).

Study populations also varied from one publication to another; publications compared surgical cases and healthy controls, or a range of medical and surgical colic cases with non-colic diseases, with no healthy control. In the opinion of this author, the most useful comparison for general practice is between medical and surgical cases, which measures the value of a diagnostic test in the differentiation of surgical cases. In this manner, were such a test developed and validated it might reduce the need for surgical intervention. Validation would require investigation of diagnostic test accuracy which could be used to estimate the probability of a case requiring surgical intervention after performing the test (Irwig *et al.*, 2002). Results of diagnostic accuracy tests in general practice has huge relevance to veterinary practitioners, since the most important question at the primary assessment of a case of abdominal pain is 'Does this horse need surgical intervention or not?' (Johnston, 1992).

None of the studies examined here used a suitable study design for assessing diagnostic test accuracy. Most of the investigations were performed in referral hospitals and were case-control studies likely

because they are convenient and simple to organise and since they generate a lot of data (Mann, 2003). They do however have the major disadvantage of sampling bias (here being that they only considered the small percentage of the horse population seen at referral hospitals), and this directly impacts the applicability of results to the wider, general population (Mann, 2003). None of the 35 studies were based in primary practice (three studies not in referral practice were unclear about the source of the study population). Primary practice represents by far the largest population of horses, and most cases of colic are managed without referral (Tinker *et al.*, 1997a). This means, that for the majority of practitioners, there is a very small body of evidence which is directly relevant to them and the cases that they see. Results from a small section of the population cannot be extrapolated to general practice; any bias present is amplified, and results may become irrelevant to first opinion veterinary practitioners as referral cases are likely to be seen later in the course of disease (Leon *et al.*, 2011). Overstated findings can lead to premature adoption of diagnostic tests and be misleading with a direct implication on decision-making for patients (Bero and Jadad, 1997).

One of the main findings of this systematic review was that there were no publications of diagnostic test accuracy study design, and the included publications demonstrated diagnostic test 'usefulness' rather than accuracy. This measure of 'usefulness' will be affected by the circumstances of each case and the opinion of the veterinary practitioner, and therefore measurement by conventional statistical

methods of ‘usefulness’ has limitations. Furthermore, the decision whether to use different diagnostic tests is often complex (Everitt, 2011). It is not always based solely upon efficacy or accuracy, but other factors such as funding, equipment, training and practitioner confidence will affect decision-making (Everitt, 2011), particularly in first opinion/general practice (this is investigated in Chapter Five).

Studies of diagnostic accuracy are typically cross-sectional in design and require participants (horses) to receive an index test along with a reference standard and possible comparator tests (Bossuyt *et al.*, 2003; Bossuyt and Leeflang, 2008). Tests of sensitivity and specificity are required to measure diagnostic accuracy (Bossuyt *et al.*, 2003; Whiting *et al.*, 2003). The levels of sensitivity and specificity can alter depending on the study population, meaning that large scale studies of both referral and primary practice populations would be needed (Irwig *et al.*, 2002; Bossuyt and Leeflang, 2008). This would be expensive, more difficult to undertake and require collaboration between several veterinary practices, but this level of research is what is needed to improve the existing body of evidence.

Despite the absence of diagnostic test accuracy studies, this systematic review was performed to provide a summary of the current evidence and methodological features, both to highlight to veterinary practitioners what evidence is available, and its limitations, but also to provide recommendations for the design of future studies. It is recommended

that correctly designed diagnostic test accuracy studies are undertaken for abdominal pain in the horse.

Although there are disadvantages to using referral populations as stated previously, they are still important in initial studies in order to measure sensitivity and specificity using the 'gold standard' reference standard of surgery or necropsy. Developing confidence in the evidence supporting the accuracy of diagnostic tests in differentiating surgical cases is important before tests can be trialled in a field environment, where sensitivity and specificity are likely to change (Irwig *et al.*, 2002; Bossuyt and Leeflang, 2008; Simundic, 2008). An agreed suitable reference standard in the field is needed for these trials, and the outcome measure would be survival or recovery. Results from field studies would support the role of the general practitioner at the primary assessment of a case of abdominal pain when deciding if the case needs to be referred or if it can be managed at in *situ.*

An adapted form of the QUADAS tool was used for the quality assessment of the included publications despite the tool being intended for studies of diagnostic test accuracy – and designed for human studies (Whiting *et al.*, 2003; Whiting *et al.*, 2006; Koh *et al.*, 2009; Mann *et al.*, 2009). As discussed in Chapter One, methods used in the human medical field are often adopted by veterinary research in the absence of tools validated for use in the veterinary field (Wylie *et al.*, 2012; Agunos *et al.*, 2014). There was no critical appraisal tool available in either field which perfectly suited the design and focus of

the included studies, and so a close match was selected in the form of the QUADAS appraisal tool. The QUADAS tool has been validated and used in many systematic reviews (Whiting *et al.*, 2006; Mann *et al.*, 2009; Cook and Hegedus, 2011; Scaia *et al.*, 2012) and was chosen as a suitable method to establish the methodological quality and susceptibility to bias of the included publications.

Some adaptations were made to the QUADAS tool in order to ensure study findings were useful, applicable and practical to primary practice, including highlighting methodologies that could be feasibly repeated in a field environment. This was challenging because in order to identify publications which used an appropriate reference standard for surgical cases (surgery/necropsy); there was a bias to studies performed in referral populations. This was evident in the quality appraisal of the included publications, where Criterion 1: 'Was the spectrum of patients representative of the patients who will receive the test in practice?' which in this case refers to the general population, was not met by any of the publications. This was unavoidable due to the lack of an agreed 'gold standard' reference test for cases of abdominal pain requiring surgical intervention which can be carried out in a field environment, but did narrow the scope of applicability for many of the tests and parameters investigated.

This systematic review demonstrated that information on key elements of study design, conduct and analysis were often either not reported or were unclear; so the actual level of bias was not known in most cases.

In order to improve the quality of evidence, studies should adhere to reporting guidelines designed to standardise the quality and advise on the reporting of appropriate methodology to reduce susceptibility to bias (Smidt *et al.*, 2006; Simera *et al.*, 2010). If more publications followed reporting guidelines, findings between studies could be combined with possible meta-analysis of results. This would increase the evidence base and improve the quality and validity of the evidence (Smidt *et al.*, 2006; Videnovic and Metman, 2008). An example of a reporting guideline for studies of diagnostic accuracy is the STARD statement (Bossuyt *et al.*, 2003) which consists of a checklist and flow diagram to ensure the correct information is reported. Within the online author instructions of three commonly used veterinary research journals, two provide clear links to established reporting guidelines including STARD (T.V.J., 2015; V.R., 2015). One, which has been rated the fifth most useful journal publication to UK equine veterinary practitioners, does not provide any links to reporting guidelines on their website (E.V.J., 2015; Nielsen *et al.*, 2015). All journals must be relied upon to encourage authors to make use of reporting guidelines by providing clear links to statements (Simundic, 2008).

Research is needed in the tests preferentially used by practitioners in the diagnosis of equine abdominal pain and cases which require surgical intervention. Information about the reasons why veterinary practitioners prefer certain tests and the barriers which prevent them utilising particular diagnostic approaches are also needed. This information will guide researchers to the most important tests requiring

standardised evaluation through tests of diagnostic accuracy to support veterinary practitioners, and address gaps in evidence.

3.4.1 Recommendations for further work

Recommendations for research are highlighted below and covered in more detail in Chapter Seven.

1. There is a need to develop a validated critical appraisal tool for studies of diagnostic test accuracy in veterinary medicine, which would consider applicability to primary practice.
2. Consensus accepted, validated reporting guidelines are required for studies of diagnostic test accuracy in veterinary medicine. This would enable standardised methodology to be utilised by researchers.
3. All journal author instructions should include clear links to reporting guidelines to encourage authors to report research in the best possible way (Simundic, 2008).
4. There is a need for replication of diagnostic test studies with justification for alterations in methodology – and more adherence from journals to publish these studies (Neuliep and Crandall, 1993).
5. Large scale, correctly designed studies of diagnostic test accuracy for abdominal pain must be performed in the horse, as currently there are none.

3.5 Conclusion

There are no publications that use suitable methodology to assess the value of any diagnostic tests in differentiating horses with abdominal pain that require surgical intervention from those that require only medical treatment. The evidence concerning diagnostic tests is predominantly based in referral practice populations or laboratory-based, with a lack of valuable evidence from general practice. For the majority of veterinary practitioners, evidence for diagnostic tests for abdominal pain is limited and of poor quality. Commonly used diagnostic tests in primary practice such as the rectal examination require research attention, as there is no evidence to support their value in differentiating surgical cases of colic. Supportive evidence for decision-making in the diagnostic approach to colic in general practice is needed in the form of diagnostic test accuracy studies. Apart from this, there is a general requirement for more standardised study design, conduct and analysis following guidance from appropriate reporting guidelines. Abdominal pain is one of the most important and complex diseases affecting horses. The veterinary profession must recognise and address the lack of evidentiary support for front-line veterinary practitioners making significant decisions in colic cases.

LC was the main reviewer for this project, and carried out every step of this systematic review including the research, planning, execution and alterations to methodology. TC was the second reviewer and

independently read and quality assessed all the studies from abstract to full text stage. SF acted as third reviewer should another opinion be required and was available for advice and support. JB and GE were also available for advice and support. Advice on improvement to methodology and study design was received from R. Dean.

CHAPTER FOUR: Prospective study of case presentation and clinical signs on primary presentation of abdominal pain in the horse

This chapter meets the following objective: To generate evidence on how cases of equine abdominal pain present at the initial evaluation by veterinary practitioners, the diagnostic approaches chosen and treatments currently used, and the factors which influence clinician decision-making

4.1 Introduction

Abdominal pain (colic) in the horse can be caused by a plethora of pathological processes; collectively these conditions result in a disease associated with high mortality, with estimates of colic being the primary aetiology in up to 28% of all deaths (Tinker *et al.*, 1997a; Ireland *et al.*, 2011). Abdominal pain has also been ranked as the most important emergency problem by both owners and veterinary practitioners in studies by Traub-Dargatz *et al.* (1991) and Bowden *et al.* (2014). There are many possible causes of abdominal pain, and therefore diagnostic approach and assessment can be challenging to the veterinary clinician (Dukti and White, 2009). Although many cases of abdominal pain resolve with little or no treatment and may not even be reported to the veterinary practitioner (Tinker *et al.*, 1997a), a significant proportion may be critical, requiring intensive medical or surgical therapy in order to improve their likelihood of a successful outcome. An early and accurate diagnosis is of imperative importance to the critical cases and

the degree, duration and severity of pathology can all influence prognosis (Fischer, 1997).

The decision to refer a case for surgery or intensive care is built upon a variety of considerations – clinical findings and history, outcomes of diagnostic tests, owner contribution (opinion, financial situation) and veterinary practitioner confidence and experience (Johnston, 1992; Brockman *et al.*, 2008; Everitt, 2011). In human emergency medicine the process of triage, whereby patients are quickly assessed on primary presentation in order to determine the priority of their treatment is well established (Canonico *et al.*, 2008; Guyatt *et al.*, 2008). It is often used in conjunction with "red flag" protocols which are aimed at the early identification of symptoms which are associated with particular pathologies requiring rapid diagnosis and treatment (Samanta *et al.*, 2003; Downie *et al.*, 2013). In veterinary medicine, decision-making can be more difficult due to the many different types of colic and because there are significant gaps in the evidence (Dukti and White, 2009). Evidence to support decision-making for veterinary practitioners when differentiating critical cases of abdominal pain is important, and is lacking in primary practice.

Most of the current evidence on assessment and decision-making in abdominal pain in the horse is based on studies of referral hospital populations despite the high incidence of abdominal pain the general horse population, and the majority of cases beginning and ending in the field without referral (Cohen, 2003). Much of the primary evidence

relating to diagnostic approach at the first evaluation of cases of abdominal pain is found in textbooks and narrative reviews (Greatorex, 1972; Wilson and Gordon, 1987a; Archer, 2004; Southwood and Fehr, 2012) These types of publications constitute a low level of evidence with greater susceptibility to bias (Cockcroft and Holmes, 2003; Vandeweerd *et al.*, 2012a).

There are some studies which have reported on the primary presentation, evaluation and treatment of colic in the horse (Proudman, 1992; Concato *et al.*, 2000; Hillyer *et al.*, 2001; Hillyer *et al.*, 2002a). The available studies are important, but have concentrated on a specific population, such as a single practice (Proudman, 1991) a specific breed/type of equine (Hillyer *et al.*, 2001), and/or have been an epidemiological study looking at the incidence of colic rather than the veterinary practitioner's approach to the initial assessment of colic cases (Uhlinger, 1992; Kaneene *et al.*, 1997; Mehdi and Mohammad, 2006). One study by Larsen and Flaoyen (1997) is a first opinion colic survey from Norway, but consists of only 77 cases and is not easily accessed or cited in other articles.

There are two main limitations to evidence from referral hospitals. Firstly, referral hospital cases represent only a small subset of horses suffering from abdominal pain as these cases are considered to be critical and require referral treatment (Abutarbush and Naylor, 2005). In addition, the owner has already considered the financial and/or emotional value of the horse when justifying the cost of treatment

(Scantlebury *et al.*, 2014). Secondly, the data from referral hospital studies is based on the clinical presentation of the horse when it arrived in the referral hospital, rather than the first assessment performed by the practitioner who performed the primary examination (Vainio *et al.*, 2011; Schuh *et al.*, 2012). There is a requirement for research on the primary care of abdominal pain in the horse to provide evidence on clinical presentation and current veterinary practise and to aid decision-making by veterinary practitioners.

An understanding of the diagnostic approach to equine abdominal pain in general practice and its relationship to the presentation of cases is required for several reasons. There is currently no published collaborative record of the type and nature of cases that are presented to veterinary practitioners from different practices across the UK on a first opinion basis. In addition, there is a lack of understanding of the individual variation in decision-making and diagnostic approach of first-opinion equine abdominal pain at veterinary practitioner level, unlike small animal practice (Everitt, 2011). Finally, engagement with veterinary practitioners is needed to capture the complexity of the decision-making process in first-opinion equine abdominal pain, but also to build a better relationship between research and primary practice. A mutually positive experience may become important when veterinary practitioners are needed for further research (Andrew *et al.*, 2008).

The aim of this study was to describe the clinical presentation and primary assessment of cases of abdominal pain by veterinary practitioners, and to identify differences between critical and non-critical cases at the primary evaluation.

The objectives of the study were:

- To collaborate with veterinary practitioners based in a variety of types of practice, with an equine customer base.
- To collect data on the features of cases of equine abdominal pain in a range of general veterinary practices.
- To describe the clinical presentation of cases of abdominal pain on primary assessment by a veterinary practitioner.
- To evaluate the diagnostic approaches and treatments used by veterinary practitioners on primary assessment of equine abdominal pain.
- To identify clinical features which differ between non-critical and critical cases at the primary presentation of equine abdominal pain to a veterinary practitioner.

4.2 Methodology

This project was reviewed and approved by the Ethics Committee, School of Veterinary Medicine and Science, University of Nottingham.

4.2.1 Collaboration with veterinary practitioners

4.2.1.1 Sample population

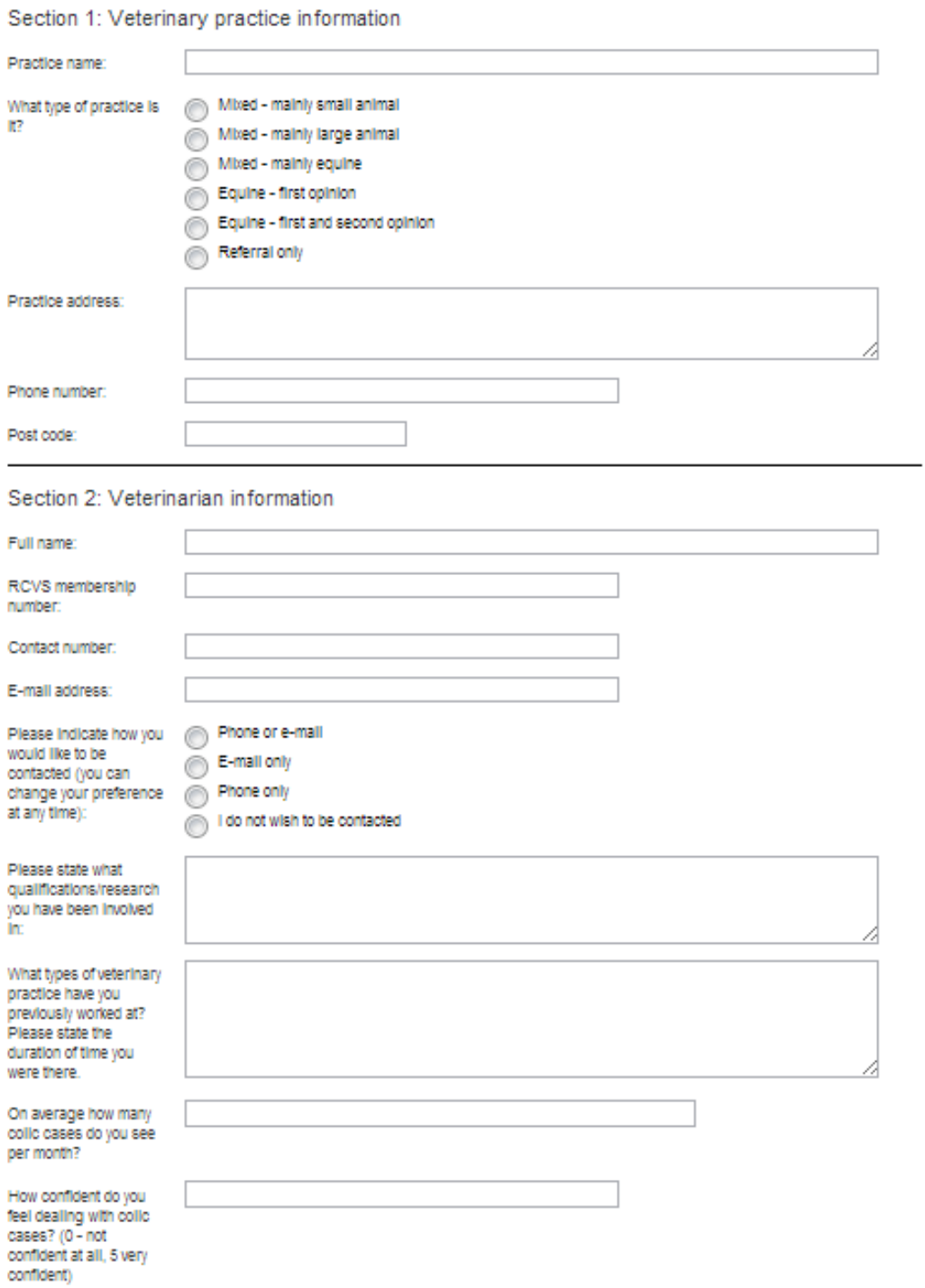
The sampling frame consisted of all veterinary practitioners within UK veterinary practices that were registered with the Royal College of Veterinary Surgeons (RCVS) and dealing with equine clients. Participants were identified using the RCVS Directory of Veterinary Practices 2010 (n=3640). This was systematically searched and practices that did not treat horses were excluded. The remaining list (n=850) of principal practices (branch practices were also excluded) became the 'Equine Practice Register' for the study who were contacted by post and asked to participate.

This probability sampling provided every equine veterinary practice within the UK that was registered with the RCVS with an equal chance of inclusion.

4.2.1.2 Colic survey registration

A short registration form was designed for completion by potential participants (Figure 10), in order to generate a register of veterinary practitioner and practice details. These data were also used to produce an overview of the demographics of the study participants (for example age, experience, current veterinary practice type). The form was available both in paper format and as an editable pdf (Adobe Forms Central, Adobe Systems Incorporated) on the www.colisurvey.com

website. A regional code was given to each practice to allow geographical analysis.



Section 1: Veterinary practice information

Practice name:

What type of practice is it?
- Mixed - mainly small animal
- Mixed - mainly large animal
- Mixed - mainly equine
- Equine - first opinion
- Equine - first and second opinion
- Referral only

Practice address:

Phone number:

Post code:

Section 2: Veterinarian information

Full name:

RCVS membership number:

Contact number:

E-mail address:

Please indicate how you would like to be contacted (you can change your preference at any time):
- Phone or e-mail
- E-mail only
- Phone only
- I do not wish to be contacted

Please state what qualifications/research you have been involved in:

What types of veterinary practice have you previously worked at? Please state the duration of time you were there.

On average how many colic cases do you see per month?

How confident do you feel dealing with colic cases? (0 - not confident at all, 5 very confident)

Figure 10. Colic survey registration form for veterinary practitioners

4.2.1.3 Website and email

A website was created (www.colicsurvey.com) to serve as an easily accessible source of information in addition to hosting the online forms that required completion by survey participants. Two email addresses were established (registration@colicsurvey.com and contact@colicsurvey.com) and were linked to the survey website to facilitate communication between the project team and potential/registered participants. The survey website was open access without subscription and consisted of the following sections: Home, Background, Profiles, Results, CPD (Continuing Professional Development), Links and Contact (Figure 11).

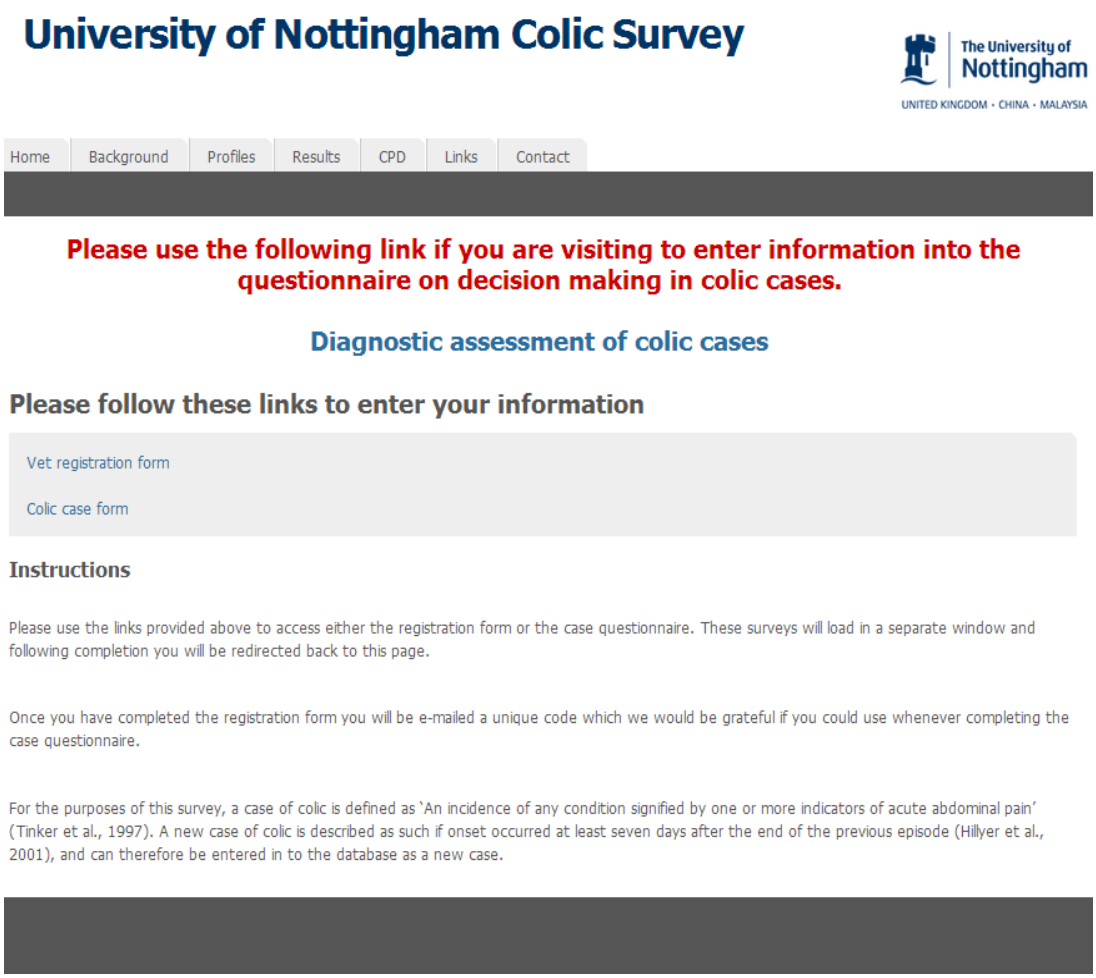


Figure 11. A print screen of the home page of www.colicsurvey.com showing the content available to website users.

4.2.1.4 Participant recruitment

Business cards were designed and printed using an online supplier of printing and promotional material (Timmermans and Mauck, 2005) (Appendix A). They were included in any mailings as a reminder to those who had forgotten to sign up to the survey. The business cards were also used during networking both by the research team and collaborators of the project.

A letter was submitted and published in the 'Letter to the Editor' section of a veterinary journal publication (Issaoui, 2012) to advertise the survey and also to give preliminary notification and prepare veterinary practices for the documentation to be posted in due course. In addition, a press release was posted on the websites of the RCVS Charitable Trust, University of Nottingham (Appendix B), and British Equine Veterinary Association (BEVA) (Appendix C) as well as being adopted by other websites including www.vetgrad.co.uk and www.thehorse.com. Halfway through the survey, a clinical commentary on colic diagnosis was published (Freeman and Issaoui, 2013), along with a half-page colour advert of the survey (Appendix D).

An information pack containing an introductory letter, business card and paper copy of both registration and abdominal pain case assessment forms, and a self-addressed postage-paid envelope were sent to all 850 practices on the equine practice register in month one. A reminder letter was distributed in month five to non-responders along with a slip for them to return with feedback and to allow them the option to decline further contact from the survey. In total 720 letters, feedback slips and newsletters were posted to non-responders and 70 newsletters were sent to registered practices (Appendix E).

A message was sent to the Nottingham Veterinary School Alumni about the survey to encourage participation and communication amongst other practicing vets across the country as well as ex-students of the University. An email was sent to all Nottingham Veterinary School fifth

year veterinary medicine students before the Christmas holidays to ask them to promote the colic survey to any veterinary practices they work with during their extra-mural studies (EMS).

4.2.1.5 Participation maintenance

A weekly email was sent to each registered member of the survey who had provided their email address. The email contained an update on the number of registered participants, contact details for the survey, a reminder to submit abdominal pain case assessment forms and any other relevant information. A text containing similar information was sent to those who opted for this option and did not wish to be contacted via email.

At the end of month four, all abdominal pain case assessment form data were downloaded from the database and basic descriptive statistics were carried out to show age, sex, body weight, body condition score, presumptive diagnosis and outcome information. This was repeated for one of the local pilot veterinary practices which had completed over 20 forms to allow comparison with the rest of the study sample. This provided the basis of the individual practice feedback. A meeting with the aforementioned practice allowed feedback on the data presentation and content before a document was produced for other well performing practices (more than 20 forms submitted). Practices which had qualified for feedback were contacted and given the choice to receive their feedback via email or personal visit. A presentation was usually delivered during a staff meeting and printed feedback was handed out

and content described. The feedback process was repeated approximately every four months during the 12 months of survey collection. An anonymised example of practice feedback can be found in Appendix F.

A newsletter was sent in month six to all veterinary practices, including those that had not responded to the initial letter, to show non responders how they could benefit from joining the survey (Appendix G). A further two newsletters were sent to survey participants in month 12 and shortly after the end of the survey (Appendix H and I). The newsletters included updates on survey progress, selected data overview, feedback opportunities for practices, information about collaborator support, conference and publication details. Christmas postcards were sent to participating practices as a 'thank you' but also to remind survey participants to keep completing and sending case assessment report forms (Appendix J). Another 'Letter to the Editor' was published in month nine containing a survey update and some feedback to the veterinary community (Issaoui, 2013).

4.2.1.6 Commercial/Industry support

Advertising for survey participation was generated from Boehringer Ingelheim (BI) in several ways:

- Advertising through direct communication between veterinary practitioners and BI territory managers.

- Advertising during presentations, webinars and other continuing professional development (CPD) sessions carried out by BI to veterinary practitioners.
- Promotion of a free prize draw for registered colic survey participants.

The researchers of the survey have no conflict of interest to declare; the support from BI was in advertising the survey only, and the colic survey had no role in promoting any medical products provided by BI.

4.2.2 Data collection on features of cases of equine abdominal pain

4.2.2.1 Abdominal pain case assessment form

A single page, two-sided assessment form was designed to allow the collection of abdominal pain case details. The case form was designed and piloted as part of a student project using 11 veterinary practices which were selected using convenience sampling and asked to participate. In the pilot study, paper colic case assessment forms were provided along with a link to an online version of the form via a web-based survey programme (Straus and McAlister, 2000). Feedback was generated from the pilot survey participants and taken forward to assist the development of the main survey. No modifications were made to the colic case assessment form between the end of the pilot stage and the start of the main project. The implementation of a predominantly online method of data collection for the main study was decided upon as

opposed to paper forms following oral feedback from the selected practices, however paper forms were still available as they have been found to generate a comparable response rate in some populations (Kaplowitz *et al.*, 2004). An improved version of the online form was designed (Adobe Forms Central, Adobe Systems Incorporated, San Jose, CA) which was available via a link on the dedicated website, and paper-based versions were mailed out to the practices with pre-paid return envelopes, depending on the veterinary practitioner's preference.

The case assessment form (Figures 12-14) was divided into five sections requiring a mix of open and closed format responses, with questions relating to dependent and independent variables, requiring continuous and/or discrete information (Iarossi, 2006). Each variable included had either been implicated in an aspect of colic research (for example age (Freeman and Schaeffer, 2001), sex (Rabuffo *et al.*, 2002) and breed (Reeves *et al.*, 1989b)) or was necessary for categorically grouping data for multivariable analysis. Behavioural observation as an indicator of pain or discomfort exhibited in the horse was successful in a study by Price *et al.* (2003). Behavioural scales were also found to be useful in recognising and assessing pain signified by lameness in laminitic horses (Vinuela-Fernandez *et al.*, 2011). Grimace scales were used to evaluate post-castration pain in stallions which offered an overall 73.3% accurate scale of measurement (Dalla Costa *et al.*, 2014). This scale does require some observer training in scoring facial expressions which would not be appropriate in this case. A behaviour-based pain severity scale is under development by Sutton *et al.* (2013)

and although valid, was thought to be too time consuming alongside the rest of the questionnaire. Section One of the colic case form for the current study (Figure 12) included a behavioural severity scale which was developed based on a rudimentary version by Mair and Smith (2005b). The scale combined individual severity scores based on the parameters 'behaviour' (kicking, pawing, flank watching and so on) and 'demeanour' (responsive, unresponsive *et cetera*). These were assessed and scored individually and summed to give a maximum total behavioural severity score of 17 (Table 16).

Table 16. Descriptors and numerical values used for the assessment of pain and demeanour (behavioural severity score) in a prospective study of the primary presentation of abdominal pain in the horse. Adapted from Mair and Smith (2005b).

Behavioural severity score	Score 0	Score 1	Score 2	Score 3
Kicking	None	Occasional	Frequent	Continuous
Pawing	None	Occasional	Frequent	Continuous
Sweating	None	Slight	Moderate	Severe
Flank watching	None	Occasional	Frequent	Continuous
Attempts to lie down	None	Occasional	Frequent	Continuous
Demeanour	Standing normally/BAR	Lowered head, no response to auditory stimulus	Twitching, agitations and continuous movement	

In addition to the basic patient information in Section One of the case assessment form, Section Two incorporated open text or tick boxes to ascertain clinical presentation (Figure 12). This included cardiovascular and respiratory indices (heart rate, respiratory rate, capillary refill time and mucous membrane colour), rectal temperature and assessment of gastrointestinal borborygmi. Gastrointestinal sound descriptors were provided in order to convert the description to a numerical value (0 = absent, 1 = reduced, 2 = normal and 3 = hypermotile) for each flank quadrant (Sasaki *et al.*, 2008). A score was recorded for each quadrant of the abdomen (maximum of three points each quadrant) and summed to calculate an overall score; where 12 was the maximum score and zero was the lowest.

Section Three (Figure 13) consisted of closed answer questions to determine the decisions made for diagnostic approach by the veterinary practitioner, such as whether palpation *per* rectum, nasogastric intubation, blood sample and/or abdominal paracentesis were performed. Open questions were included for results and details of any additional tests used which were not listed. Veterinary practitioners were also invited to identify and describe any factors that may have affected their choice of diagnostic test using specific options within the questionnaire, in addition to a free text answer box.

Section Four (Figure 13) was used to record the treatment and initial outcomes of each case. Closed question format with specific multiple choice options was used to record treatments used by veterinary

practitioners. The choices were non-steroidal anti-inflammatory drugs (NSAIDs), opioids, oral fluids, sedatives, spasmolytics, anthelmintics, laxatives and detail of other treatments (with an open text option). Open text questions were used to record the treatment names, dosages and dosage timings, and additional treatment information. At the end of Section Four, the veterinary practitioner was asked to provide a presumptive diagnosis using an open text comment box, and case outcome was entered using a multiple choice tick box. Pending outcome information was obtained by a follow up contact email/telephone call by the research team.

Additional case information such as current management and use of the horse, recent changes (weather, diet and exercise for example), previous health problems and prophylaxes (dental and anthelmintic) was recorded in Section Five (Figure 14). A mix of open and closed questions were utilised for Section Five including a free text box at the end of the section for any other information (for example difficulties with horse temperament during assessment, owner wishes, unusual developments and RSPCA cases).

Various contact methods were provided for any participants to return paper forms, access the web-based case assessment form and/or discuss the survey with the researchers (post, email, fax, website).


Section 1: Case presentation and history

Clinician reference number:*

Date of examination:

Horse name:

Breed:

Age (years):

Sex: Mare Gelding Stallion

Body condition score: Thin Moderate Overweight

Approximate weight (kg):

Presenting history including nature, severity and duration of clinical signs

Kicking: None Occasional Frequent Continuous

Pawing: None Occasional Frequent Continuous

Sweating: None Slight Moderate Severe

Flank watching: None Occasional Frequent Continuous

Attempts to lie down: None Occasional Frequent Continuous

Demeanour: Standing normally/, BAR Lowered head, no response to auditory stimulus Twitching, agitations and continuous movement

Please continue to section 2

Section 2: Physical examination on presentation

Heart rate (beats per minute):

Resp. rate (beats per minute)

Rectal temperature

Capillary refill time: <2.5 seconds >2.5 seconds

Mucous membrane colour: Pink Red Cyanotic

Pulse character: Weak Strong

Auscultation of intestinal sounds: right upper flank

Auscultation of intestinal sounds: right lower flank

Auscultation of intestinal sounds: left upper flank

Auscultation of intestinal sounds: left lower flank

Any other observations on physical examination (e.g. abrasions, abdominal distension etc.)

Please continue to section 3.

Figure 12. Online abdominal pain case assessment form – Sections 1-2

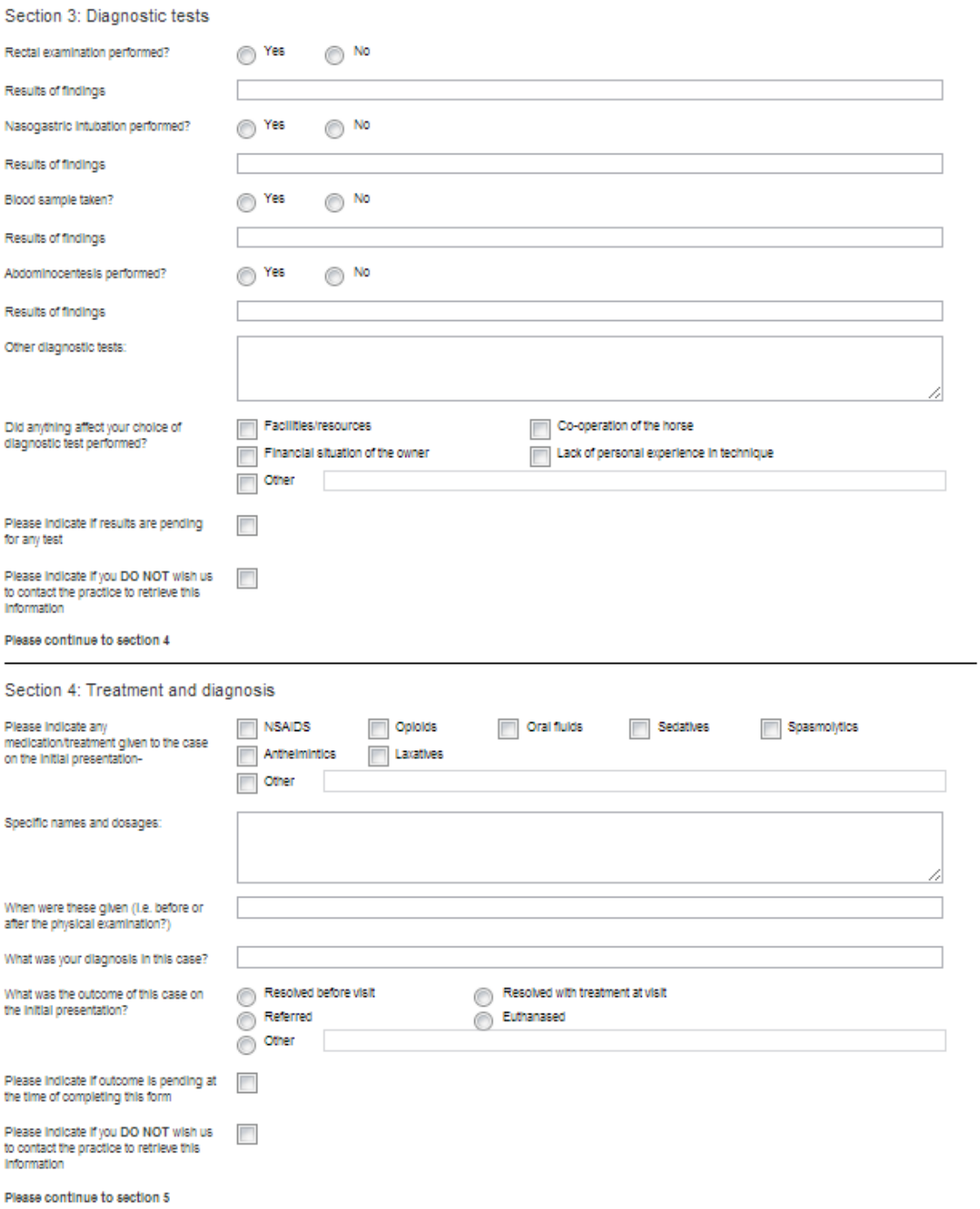


Figure 13. Online abdominal pain case assessment form – Sections 3-4


Section 5: Additional case information

Does this horse have any ongoing or previous health problems? Yes No

Details of other health problems

If this case has previously been examined for an episode of colic and entered into the database please provide an approximate date

Date last wormed

Drug(s) used

Any additional information (e.g. pasture management, faecal egg count results, tapeworm ELISA)

How often does the horse receive dental care? Every 6 months or less Every 6 to 12 months Every 1-2 years Never

Who is this performed by? Equine dental technician Veterinary surgeon

Housing Kept at owner's property DIY livery Full livery Stabled Grass turnout

Exercise Ridden 7 days/week Ridden 3-6 days/week Ridden 1-2 days/week Not ridden

Feed Horsehage Hay Silage Pony/grass nuts Concentrates Other

Has there been any recent change in management (e.g. change of feed, a period of box rest)?

Had the horse passed faeces in the previous six hours? Yes No

Details of consistency, amount etc.

Additional information (e.g. hours stabled, whether turned out at grass)

Please use this section to record any further information (e.g. additional drugs, response to treatment etc.)

Thank you for completing this form. We are extremely grateful for your time and assistance. If you would like to contact us please do so using the details available on the website.

Figure 14. Online abdominal pain case assessment form – Section 5.

Veterinary practitioners were asked to complete one form for every primary case presentation of colic assessed. Colic was defined as 'Any incidence of abdominal pain as assessed by the veterinary practitioner in attendance', and seven days free of abdominal pain was required for a case to be considered unrelated to a previous episode (Hillyer and

Mair, 1997). Otherwise, any further visits carried out and subsequent forms for the same horse were classified as the same case of colic.

Diagnosis of each case of abdominal pain was decided by the attending veterinary practitioner, although new cases could be classified by the research team through calculation of the dates provided on the case assessment form. Any additional forms submitted for each case were saved and the eventual case outcome was recorded. For any cases where the outcome was pending when the form was submitted, the participants were contacted after approximately one month for follow up information to ensure an effort to record a final case outcome was made.

The data from each case assessment form were downloaded every month from the survey website and descriptive statistics of case numbers, subject data (age, gender, breed) and case types (based on presumptive diagnosis) were used to monitor survey progress.

4.2.3 Data sorting and analysis

Data were entered into a statistics programme (SPSS Statistics Version 21, IBM Corporation, 2012). Descriptive statistics (mean, mode, median, range and standard deviation) were carried out for each of the continuous variables and percentage frequencies were calculated for all categorical data.

An *a priori* power calculation was carried out using Power Analysis and Sample Size (PASS) software to calculate the minimum sample size

required to see a real effect (80% power) and reduce the chance of type II error.(PASS 11, NCSS, Utah, USA). The software was used to determine the sample size considering an acceptable power of 80% and confidence intervals of 95%. The calculation output proposed a sample size of n=719 to yield a statistically significant result.

The case diagnosis was recorded as an open text comment. Case diagnoses from all cases were reviewed at the conclusion of the study and categorised into four main categories (Table 17):

1) No definitive diagnosis (subcategorised into spasmodic, gas/tympanitic, and unknown).
2) SCOD (simple colonic obstruction and distension (Hillyer *et al.*, 2002a)), subcategorised into large colon impaction and large colon displacement.
3) Surgical/strangulating lesion (subcategorised according to lesion location)
4) Other conditions (subcategorised according to lesion location/type)

The diagnosis category was determined by reviewing the veterinary practitioner's presumptive diagnosis, presenting signs, physical examination findings, diagnostic test findings, further information provided by the veterinary practitioner and final outcomes recorded. If final outcomes were pending when the form was submitted, participating veterinary practitioners could provide details if they wished to be contacted subsequently for further information. The category

definitions and inclusions were generated and discussed by three researchers (LC, JB and SF), and the data were reviewed and categorised by one researcher (SF).

Cases in which outcome was not completed or not known at the time of submission were followed up by contacting the veterinary practice (if consent had been given by the veterinary practitioner). The case outcome was recorded as closed answer response from options of 'resolved before visit', 'resolved with treatment at visit', 'referred', 'euthanased' or 'other'. For cases that were referred and for those with outcomes pending, the veterinary practitioners were able to indicate if they consented to be contacted for case follow up to be obtained; cases with consent were followed up to determine final outcome and diagnosis.

For the purposes of this study, two sub-groups (non-critical and critical) were extracted from the overall case population by retrospective classification of cases after they had reached outcome. Non-critical cases were defined as cases exhibiting signs of gastro-intestinal pain at the time of the clinical examination which responded positively to simple medical treatment. This group therefore did not include cases which had resolved prior to examination or which required intensive hospitalised treatment. Critical cases were defined as all instances where the animal was hospitalised to receive critical care (either intensive medical treatment and/or surgical intervention) at any point during the single episode of colic, or where the animal died or was

euthanased on humane grounds as a result of the condition. All other scenarios where individuals were hospitalised for treatment deemed non-critical, or if euthanasia was performed due to factors not directly associated with the current disease were not included. Cases were excluded from the study if information regarding the nature of the disease or outcome did not allow the case to be identified in one of these two categories. Any forms detailing episodes of treatment for donkeys or mules were also excluded.

Table 17. Categories of disease causing colic from a survey of veterinary practitioners' primary assessment of horses presenting with abdominal pain.

Disease categories were determined retrospectively by reviewing the veterinary practitioner's diagnosis, presenting signs, physical examination findings, diagnostic test findings, further information provided by the veterinary practitioner and final outcomes recorded.

Disease category	Definition / inclusion criteria for disease category and sub-category
1. No definitive diagnosis	Cases in which a definitive diagnosis was not determined either at the primary or any subsequent assessments
Sub-category: Spasmodic	Inclusion criteria: Diagnosis described by veterinary practitioner as spasmodic, no abnormalities on rectal examination, and resolved with medical treatment. Exclusion criteria: Cases that were subsequently found to have other lesions (e.g. strangulating lesion) were excluded and were categorised according to the final diagnosis/ outcome of the case. Cases described as spasmodic, but with gas distension identified on rectal examination were excluded, and categorised as Category 1: No definitive diagnosis, Sub category: Gas.
Sub-category: Gas	Inclusion criteria: Diagnosis described by veterinary practitioner as gas/ tympanitic /diagnosis not determined, and findings of gas distension of intestines on rectal examination, with no underlying cause of distension identified. Exclusion criteria: Cases with gas distension associated with another lesion (e.g. impaction, displacement or torsion). These were excluded and categorised according to the primary lesion.
Sub-category: Unknown	Inclusion criteria: Diagnosis described by veterinary practitioner as unknown, or cases where the proposed diagnosis could not be confirmed from diagnostic work up. This included cases where the veterinary practitioner had given a diagnosis, but where there were no clinical or diagnostic findings to support this decision (e.g. cases reported as 'impactions' where no rectal examination was performed, recurrent or geriatric cases euthanased for colic with mild signs of pain, no rectal findings and no post mortem results)

2. SCOD (impaction or simple displacement)	Defined as simple obstruction with subsequent distension (SCOD) of the large colon (Hillyer et al. 2002). Diagnosed on the basis of positive findings on rectal examination either at the primary or any subsequent assessments, and resolved with medical treatment.
Sub-category: Large colon impaction	Inclusion criteria: Positive finding of a primary large colon impaction on rectal examination. Exclusion criteria: Cases which were diagnosed as impactions, but had negative rectal findings, or no rectal examination, were excluded from this category, and were categorised as Category 1. No definitive diagnosis, Sub category: Unknown. Impactions with a positive sand test were excluded and categorised as a separate sub-category under Category 4: Other. Cases which required surgical intervention, euthanasia or died were excluded and classified into Category 3: Surgical / strangulating lesion.
Sub-category: Large colon displacement	Inclusion criteria: Positive finding of a large colon displacement on rectal examination (including palpation of a left dorsal displacement, right dorsal displacement, pelvic flexure retroflexion or abnormal taenial bands). Exclusion criteria: Cases which were diagnosed as possible displacements, but had negative rectal findings, or no rectal examination, were excluded from this category, and were categorised as Category 1: No definitive diagnosis, Sub category: Unknown. Cases which required surgical intervention, euthanasia or died were excluded and categorised under Category 3: Surgical / strangulating lesion.
3. Surgical / strangulating lesion	Cases that required surgical treatment, were euthanased or died due to surgical or strangulating lesions, either at the primary or any subsequent assessments. This was confirmed at surgery, or post mortem findings, or where these were not available, based on severity of pain, and clinical and diagnostic findings.
Sub-category: Small intestinal lesion	Inclusion criteria: Identification of a small intestinal lesion at surgery or post mortem, or where these were not available, positive rectal findings of small intestinal distension. Exclusion criteria: Cases which had a diagnosis of suspected small intestinal strangulation, but no positive rectal findings to support this were categorised as Sub-category: No lesion site identified.

Sub-category: Large intestinal lesion	Inclusion criteria: identification of large intestinal lesion at surgery or post mortem, or where these were not available, positive rectal findings of large intestinal distension. This sub category includes large colon displacements which had surgical treatment or were euthanased. Exclusion criteria: Cases which had a diagnosis of suspected large intestinal strangulation, but no positive rectal findings to support this were categorised as Sub-category: No lesion site identified.
Sub-category of other location	Inclusion criteria: Identification of an intestinal lesion which does not meet the criteria for other sub categories (e.g. gastric obstruction and small colon strangulation). Confirmed at surgery or post mortem
Sub-category: No lesion site identified	Inclusion criteria: Cases where the site of the surgical lesion was not determined, including surgical cases where the data could not be obtained, and horses that were euthanased or died with no rectal examination, or no findings on rectal examination and no post mortem.
4. Other	Cases where a definitive diagnosis was obtained either at the primary assessment or subsequent investigations, and which did not have either SCOD or a surgical/ strangulating lesion
Sub-category: Gastric disease	Inclusion criteria: Equine gastric ulcer syndrome (EGUS) diagnosed by endoscopy.
Sub-category: Simple SI obstruction	Inclusion criteria: Clinical findings of distended small intestine on rectal or ultrasound examination of thickened small intestine, and resolved with medical treatment.
Sub-category: Caecal disease	Inclusion criteria: Primary clinical findings of abnormalities of the caecum identified on rectal examination, including caecal tympany, caecal impaction and typhlitis which resolved with medical treatment.

Sub-category: Small colon obstruction	Inclusion criteria: Positive finding of impaction of the small colon on rectal examination, which resolved with medical treatment.
Sub-category: Rectal impaction	Inclusion criteria: Positive finding of impaction of the rectum on rectal examination, or meconium impaction, which resolved with medical treatment
Sub-category: Grass sickness	Inclusion criteria: Euthanased with a diagnosis of grass sickness confirmed by ileal biopsy, post mortem or clinical signs (ptosis, dysphagia, sweating)
Sub-category: Neoplasia	Inclusion criteria: Neoplasia confirmed on surgery or post mortem on the primary assessment or subsequent assessments. Exclusion criteria: Cases where the veterinary practitioner had diagnosed neoplasia based on history (but this was not confirmed), were excluded and categorised as Category 1: No definitive diagnosis, Sub-category: Unknown.
Sub-category: Parasitic	Inclusion criteria: Worms seen in faeces, or history of no worming regime, or high faecal egg count (>800epg), or positive surgical or post mortem findings, or clinical history and laboratory results consistent with cyathastomiasis (young horse with diarrhoea and hypoalbuminaemia). Exclusion criteria: Cases with a suspected diagnosis of parasitic disease, but with no diagnostic findings to support this.
Sub-category: Peritonitis / PUO	Inclusion criteria: Cases which were pyrexic, with no underlying cause identified (PUO) or peritonitis confirmed on abdominal paracentesis
Sub-category: Enteritis, colitis or enterocolitis	Inclusion criteria: Presence of diarrhoea, ultrasound or surgical findings consistent with colitis or enteritis, at primary or subsequent assessments

Sub-category: Sand colic	Inclusion criteria: Positive sand test (faecal sand test or on radiography), inclusive of cases which presented with impaction or diarrhoea, or those that were just described as 'sand colic'. Exclusion criteria: Cases that were described as having a diagnosis of sand colic, but this was not confirmed by positive sand tests were classified as Category 1: No definitive diagnosis, Sub-category: Unknown.
Sub-category: Rupture of GI tract	Inclusion criteria: Cases which had a rupture or tear of the gastrointestinal (GI) tract identified at surgery or post mortem, regardless of location.
Sub-category: Non-GI causes	Inclusion criteria: Cases with a non-gastrointestinal problem confirmed by other clinical findings or diagnostic tests. This included cardiac disease diagnosed on auscultation and clinical signs of cardiac failure, choke, haematuria, hepatic disease diagnosed based on blood biochemistry and 'maggots in sheath', diagnosed on physical examination, urticarial / allergic reaction and muscle abscess. Exclusion criteria: Cases where suspected diagnosis was not / could not be confirmed, including cases of suspected toxin ingestion.

4.2.6.1 Statistical tests

Descriptive statistics were used for preliminary exploration of the data. The mean, median, mode, range and standard deviation was calculated for each of the continuous variables and percentage frequencies were calculated for all categorical data. Free text responses were analysed thematically and coded, and descriptive analysis performed to generate a frequency statistic for each category.

Recruitment of diagnostic tests overall and between non-critical and critical groups was assessed using Chi-squared tests. Indices relating to the signalment, history and clinical presentation of cases were compared between critical and non-critical cases using logistic regression. Screening was performed to determine the degree of association of independent continuous and categorical variables with the dependent outcome variable (non-critical/critical) using univariable logistic regression Variables with a likelihood ratio test statistic (LRTS) of <0.2 were considered for inclusion in the multivariable model. Linearity of the continuous variables was assessed using generalised additive models (GAM). Pearson correlation coefficients were used for continuous data to investigate the association of these variables. The importance of biologically plausible interactions was assessed by including these terms within the model. Variables with >20% missing data were initially excluded before being retested. Terms were added to the model in a forward, stepwise manner, with each included if they significantly improved the fit using the LRTS ($P<0.05$). Analysis of

residuals was performed to assess outlying data which were tested by exclusion from the data to ensure they did not apply excessive leverage to the model. Data analyses were performed using SPSS V21.0 (IBM Corporation) and R x64 3.0.2 (www.r-project.org).

4.3 Results

4.3.1 Collaboration with veterinary practitioners

The first objective of this work was to collaborate with veterinary practitioners based in a variety of types of practice, with an equine customer base. Veterinary practitioners across the United Kingdom were invited to register and participate in the colic survey.

4.3.1.1 Participating veterinary practitioners

Over the course of the survey 196 veterinary practices were registered (Table 18). Practices were located mostly within the UK, however registrations were also accepted from European countries and other continents, depending on whether the management conditions of the animal described were comparable to those in the UK and Europe (Figure 15). Data were submitted on cases by 167 veterinary practitioners working at 108 different practices (12.3% of the practices that were contacted) (Table 19). The type of practices (n = 108) were equine first and second opinion (30% (32/108)), equine first opinion (24% (26/108)), mixed practice – mainly small animal (21% (23/108)),

mixed practice – mainly large animal (19% (21/108)) and mixed practice – mainly equine (6% (6/108)) (Figure 16).

The number of individual veterinary practitioners registered over the duration of the survey totalled 287, with data submitted on cases seen by 167 veterinary practitioners (58.2%). Most of the registered veterinary practitioners had experience of working in equine only or mainly equine practise (72%, 170/236), and length of experience as a veterinary practitioner (where provided) ranged from three months to 38 years.

Table 18. Number of veterinary practices in each geographical region registered with a prospective survey of cases of equine abdominal pain.

Region	**Number of registered practices**
UK North	16
UK North East	18
Isle of Man	0
UK North West	14
UK Yorkshire and Humberside	13
UK East Midlands	16
UK Wales	9
UK West Midlands	13
UK East Anglia	22
UK South West	29
UK London	0
UK South East	30
UK Northern Ireland	3
Ireland	1
Channel Islands: Jersey, Guernsey, Alderney, Sark, Herm	2
Europe	3
North America	1
South America, Argentina	1
Africa	1
Oceania, Australia, New Zealand	0
Asia, Japan, China, India	4

Figure 15. Location of UK veterinary practices registered with a prospective survey of cases of abdominal pain (GeoBasis-DE/BKG; Google, 2013).

Table 19. Number of cases submitted by 167 practitioners who participated in a survey of the primary assessment horses presenting with abdominal pain.

Number of submitted cases	**Number of veterinary practitioners**
1-10	144
11-20	12
21-30	9
30-40	2

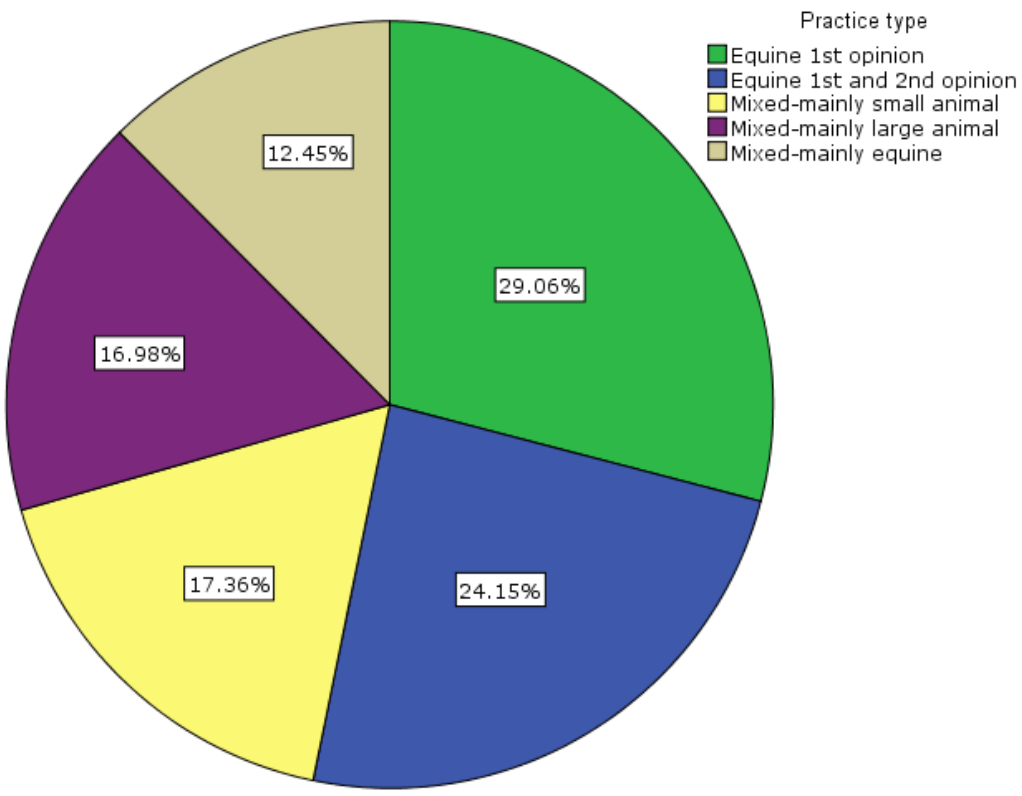


Figure 16. Type of veterinary work undertaken by 108 practices participating in a prospective study of the primary assessment of equine abdominal pain.

4.3.2 Data collection on the features of cases of equine abdominal pain

The second objective of this work was to collect data on the features of cases of equine abdominal pain in a range of general veterinary practices.

A total of 1064 abdominal pain case assessment report forms were submitted. Most forms were completed online (n=958); 106 case forms were completed by hand and either collected in person by a member of the research team (n=52), posted (n=49) or faxed (n=5). Case

assessment forms which had been submitted in duplicate were excluded (n=16). Forms containing information on subsequent visits (n=31) were used to inform the categorisation of outcome, final diagnosis and any missing basic information (for example age, body condition score) but were not used for any other analyses. 1016 case forms related to the primary assessment of individual cases and were subjected to further analysis.

Veterinary practitioners did not complete all data fields for some cases, and therefore the number of cases where data were recorded is given as (n=) for each parameter. Veterinary practitioners were requested to complete data on all cases of abdominal pain seen, but the researchers were unable to verify the percentage of actual cases seen that had assessment forms submitted.

4.3.2.1 Study case population

The cases of abdominal pain in this study consisted of 55.5% (559/1008) geldings, 41.2% (415/1008) mares and 3.4% (34/1008) stallions with a mean age of 13.5 years (median 12.0, range 0 - 42). Estimated body condition of the cases was 69.8% (692/992) moderate, 15.5% (154/992) overweight and 14.7% (146/992) thin. Fifty different breeds/types of equid were described (Table 20).

Table 20. List of breeds/types of equine described by veterinary practitioners on primary presentation of abdominal pain case report forms.

Section	Breed or Type
1	Donkey
2	Small Pony, Shetland, Welsh Section A, Miniature breeds, Falabella
3	Pony, Welsh Section B,C, 13-15hh pony, Icelandic, Connemara, Riding school pony, Highland pony, New Forest, Dartmoor, Fjord, Dales
4	Arab, Arab X, Anglo Arab
5	Cob type, Welsh Section D
6	*TB, **TBx (except ***IDxTB), Polo pony, Morgan, Selle Française. Appaloosa, Trotter/Standardbred, Quarter horse
7	$^{+}$WB, $^{++}$ISH, Hunter, Sport horse, Andalusian, Lusitano, IDxTB, Zangersheide, Spiti, Oldenburg, Fresian, Irish Draft, Criojo
8	Heavy horse, Shire, Clydesdale
9	Cross breed unknown, Riding horse

*TB= Thoroughbred, **TBx= Thoroughbred crossed with another breed/ type, ***IDxTB= Irish Draught horse crossed with Thoroughbred, $^{+}$WB= Warmblood, $^{++}$ISH= Irish Sport Horse

4.3.2.2 History and management of cases

Management history was recorded in 759 (74.7%) case assessment forms. A recent (within two weeks) management change was reported in 47.0% (357/759) cases; alterations in diet/bedding (21.5% (77/357)) and in turnout (20.7% (74/357)) were the most frequently reported changes (Figure 17). Data on frequency of dental care was recorded in 588 cases, and of these 17.5% (103/588) were reported as having received no routine dental care, 10.2% (60/588) received dental care every 0-6 months, 47.8% (281/588) every 6-12 months, and 24.5%

(144/588) every 1-2 years (Figure 18). Dental care was carried out by the veterinary practitioner in 57.5% (272/473) and by an equine dental technician in 42.5% (201/473) of cases (Figure 19).

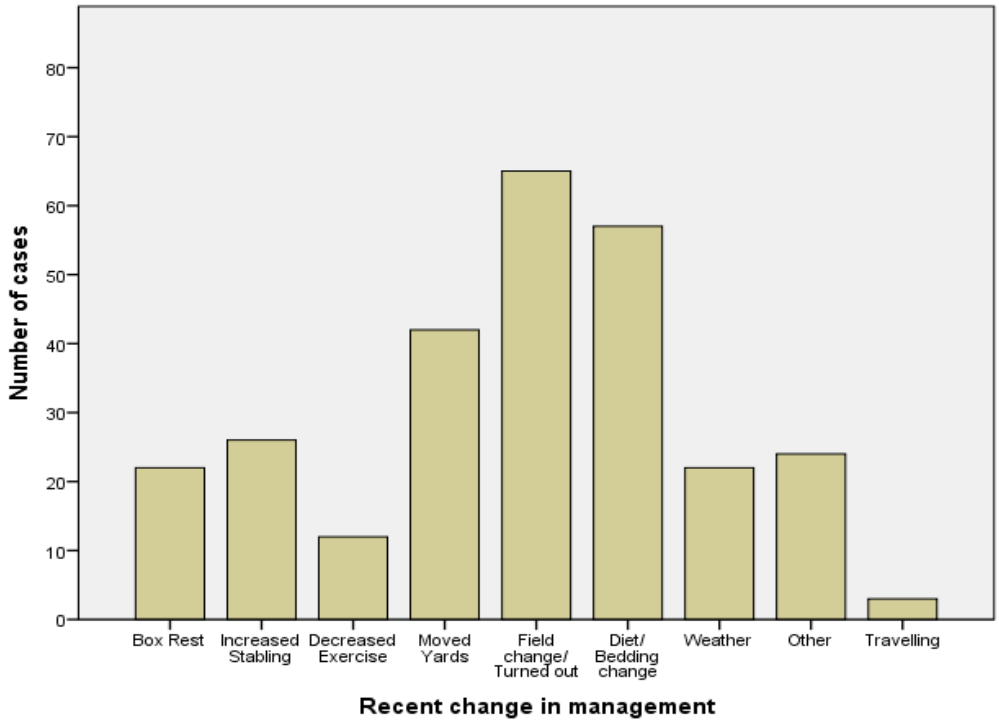


Figure 17. Recent changes in management reported on 759 primary abdominal pain case assessment report forms by veterinary practitioners.

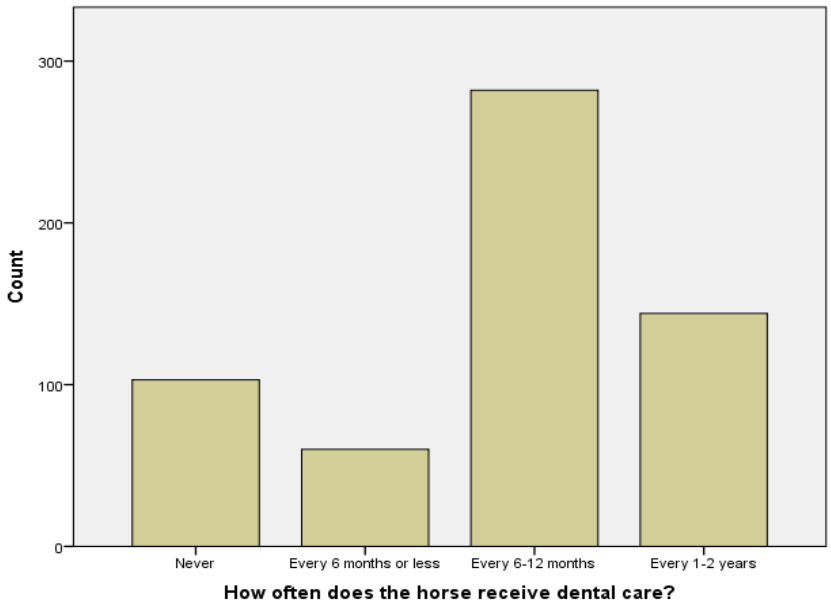


Figure 18. Dental care routine for 589 equines as recorded by veterinary practitioners on primary assessment abdominal pain case report forms.

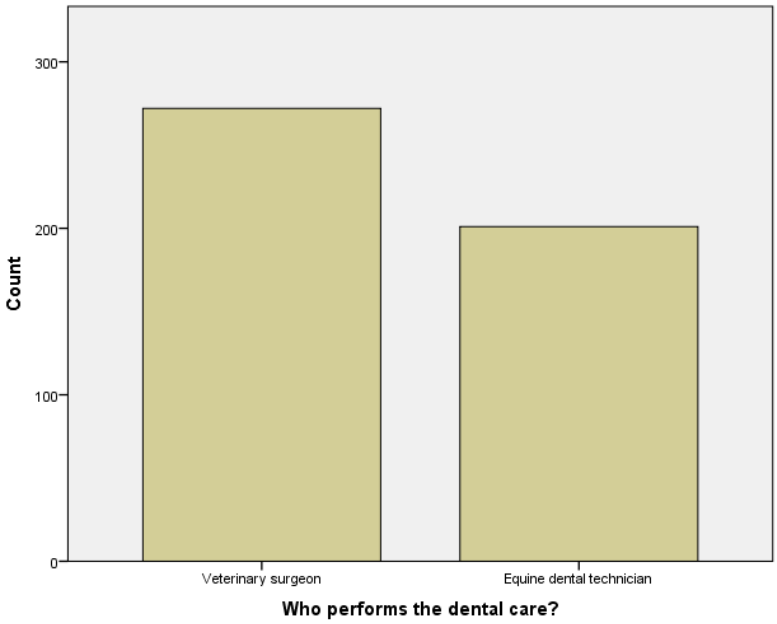


Figure 19. Dental care provider for 473 equines as recorded by veterinary practitioners on primary assessment abdominal pain case assessment forms.

Data on anthelminitic prophylaxis was provided in 44.8% of case assessment forms (456/1016). The name of the drug/s used was not available or known in 28.9% of cases (132/456), and a mix of ivermectin and praziquantel or moxidectin and praziquantel were the most popular choices of anthelmintic (16.9% (75/456) and 16.4% (77/456) respectively) (Figure 20).

Horses were not ridden in 39.5% (341/864) of cases, ridden 1-2 times per week in 21.5% (186/864), ridden 3-6 times per week in 33.0% (285/864) and ridden 7 times per week in 6% (52/864) of cases (Figure 21). The mean (+/- s.d.) duration of signs of abdominal pain (time since horse was last seen 'normal') was 8.7 +/- 18.64 hours for non-critical cases, and 10.64 +/- 19.43 hours for critical cases, and the duration was not significant within the univariable statistical model (p=0.453).

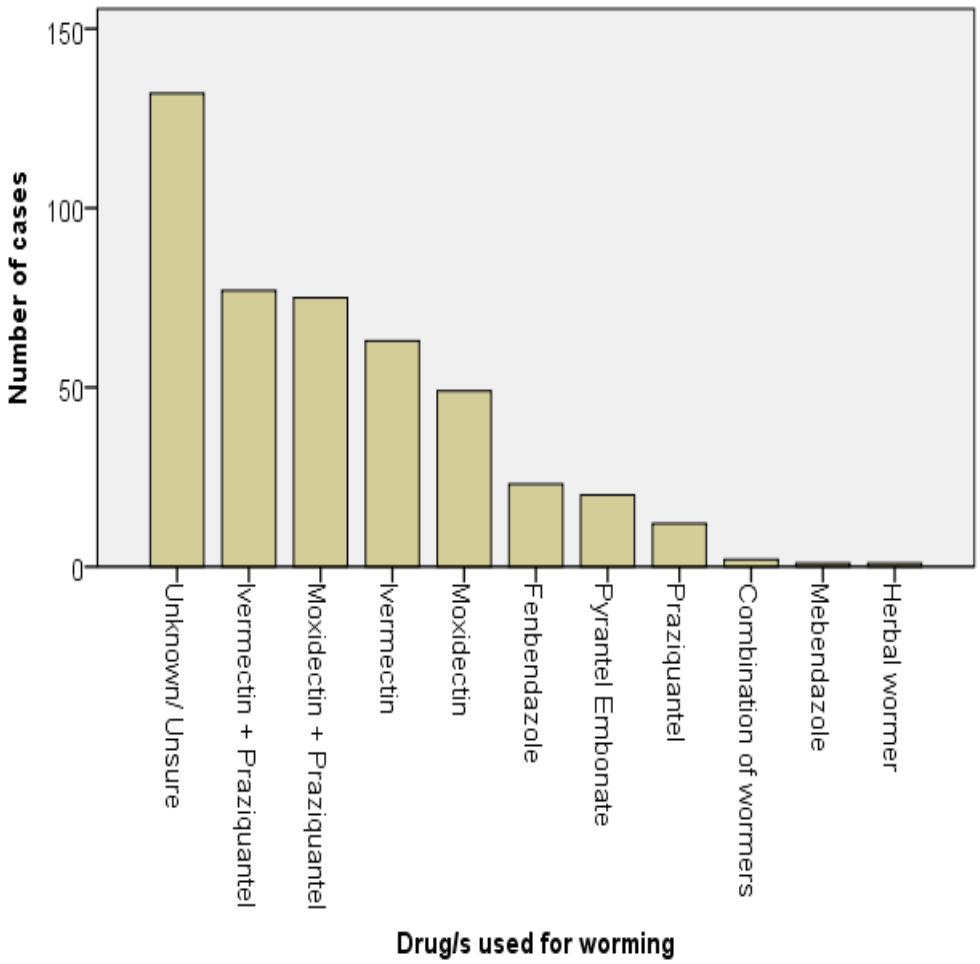


Figure 20. Previously administered anthelmintic data provided on 456 case report forms during primary assessment of cases of equine abdominal pain by veterinary practitioners.

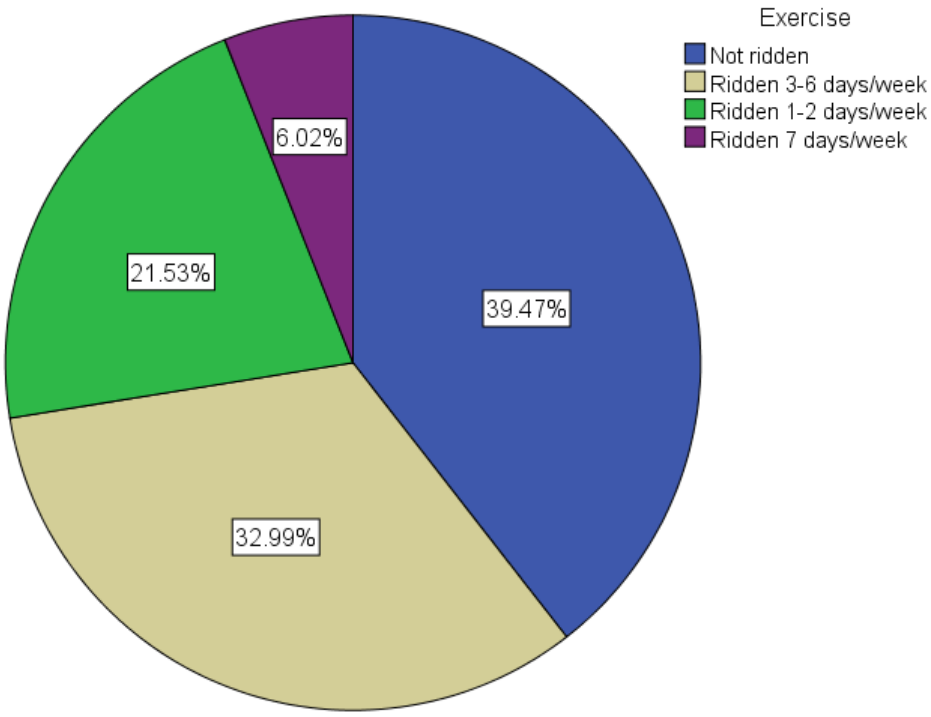


Figure 21. Exercise regime of 864 horses recorded on primary abdominal pain case assessment report forms by veterinary practitioners.

4.3.3 Clinical presentation of cases

The third objective of this work was to describe the clinical presentation of cases of abdominal pain on primary assessment by a veterinary practitioner.

On an abdominal pain behavioural severity scale ranging from 0-17, 70.4% of cases (716/1016) scored 0-6 and 29.6% (301/1016) scored 7-12 (Table 21).

Table 21. Behavioural severity score for signs of abdominal pain in 1016 equines in a prospective study of the primary assessment of abdominal pain.

Behavioural severity score	Score 0 (none/ normal)	Score 1 (mild/ occasional)	Score 2 (moderate/ frequent)	Score 3 (severe/ continuous)
Kicking	57.5% (558/971)	30.3% (294/971)	10.9% (106/971)	1.3% (13/971)
Pawing	40.1% (388/968)	38.4% (372/968)	19.4% (188/968)	2.1% (20/968)
Sweating	55.8% (542/972)	24.1% (234/972)	14.3% (139/972)	5.9% (57/972)
Flank watching	31.8% (306/961)	46.4% (446/961)	20.2% (194/961)	1.6% (15/961)
Attempts to lie down	22.8% (226/991)	29.7% (294/991)	32.0% (317/991)	15.5% (154/991)
Demeanour	50.3% (486/967)	18.0% (174/967)	31.7% (307/967)	

Mean heart rate of colic cases was 47 beats per minute (median 44, range 18-125; s.d.+/- 15.4), mean respiratory rate was 20 breaths per minute (median 16, range 6-100; s.d.+/- 12.4) and mean rectal temperature was 37.6°C (range 33.0 – 40.3). Mucous membranes were pink in 91.7% (911/993) of cases, red in 5% (50/993) and cyanotic in 3.2% (32/993) of cases. Capillary refill time was <2.5 seconds in 92% (905/984) of cases and >2.5 seconds in 8% (79/984) of cases. The median total gut score was 5 (range 0-12).

4.3.6 Diagnostic approach

At the primary examination, assessment of pain and behaviour was performed in 100% of cases (1016/1016), heart rate was recorded in

98.9% (1005/1016) of cases, respiratory rate in 89.4% (908/1016) and rectal temperature in 81.4% of cases of abdominal pain (827/1016). Gastrointestinal sounds were recorded in 98.7% (1003/1016) of cases.

A rectal examination was performed in 73.8% (743/1007) of cases, 35.6% (348/978) underwent nasogastric intubation, 18.1% (175/969) had a blood sample taken for various haematological and biochemical measurements and abdominal paracentesis was carried out in 7.3% (70/964) of cases. Additional diagnostic tests included ultrasound, faecal sedimentation test and faecal worm egg count which were performed in 3.4% (35/1016), 2.5% (25/1016) and 2.0% (20/1016) of cases respectively.

In 52.1% (529/1016) cases, veterinary practitioners recorded that there were factors that affected their decision-making. The three most commonly identified factors that affected the choice of diagnostic tests were, “Mild nature of colic, diagnostic tests unnecessary” (21% frequency), “Co-operation of the horse” (19% frequency) and, “Financial situation of the owner” (16% frequency) (Figure 22).

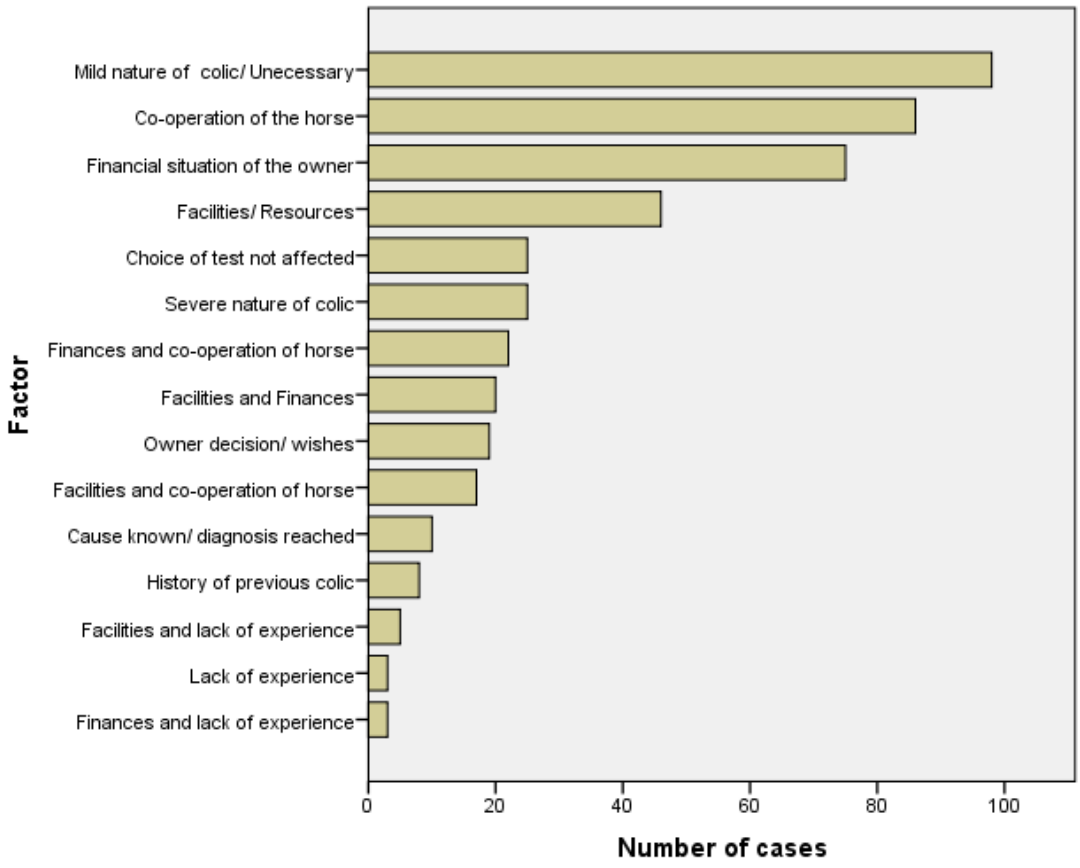


Figure 22. Factors that affected choice of diagnostic tests in the primary assessment of 1016 cases of equine abdominal pain evaluated by 167 veterinary practitioners.

4.3.4 Diagnostic approaches and treatments to cases

The fourth objective of this work was to evaluate the diagnostic approaches and treatments used by veterinary practitioners on primary assessment of equine abdominal pain.

4.3.4.1 Presumptive case diagnosis

Table 22 shows a detailed breakdown of the number of cases within each diagnostic category and subcategory. 57.1% of cases (580/1016) met the criteria for disease Category 1: No definitive diagnosis, sub-

categorised as ‘spasmodic’, ‘gas’, and ‘unknown’. The criteria for disease Category 2: SCOD (simple colonic obstruction and distension) was met by 15.3% of cases (155/1016), and were sub-categorised as ‘large colon impaction’ and ‘large colon displacement’ (Table 22). The majority of cases in disease Category 2 were described by veterinary practitioners as ‘impactions’ or ‘displacements’, and the term ‘SCOD’ was only used by veterinary practitioners to describe findings or diagnosis in two of the 1016 cases. The criteria for disease Category 3: Surgical/strangulating lesions was met by 17.5% of cases (178/1016). These were sub-categorised as ‘small intestinal lesion’, ‘large intestinal lesion’, and ‘other location’ or ‘no lesion site identified’. The criteria for disease Category 4: Other diagnosis was met by 10.1% of cases (103/1016), which included a range of other disease types, including non-gastrointestinal causes of colic (Table 22).

Table 22. Number of horses presumptively diagnosed with different categories of disease in 1016 horses from a survey of veterinary practitioners' primary assessment of horses presenting with abdominal pain.

Disease category	Number of cases
1. No definitive diagnosis	**580**
Sub-category: spasmodic	*254*
Sub-category: gas	*68*
Sub-category: unknown	*258*
2. SCOD (impaction or simple displacement)	**155**
Sub-category: large colon impaction	*121*
Sub-category: large colon displacement	*34*
3. Surgical / strangulating lesion	**178**
Sub-category: si lesion	*72*
Sub-category: li lesion	*36*
Sub-category: other location	*2*
Sub-category: no lesion site identified	*68*

4. Other	**103**
Gastric diseases (EGUS)	2
Simple SI obstruction	7
Caecal disease	7: *Caecal tympany (n=4), caecal impaction (n=2), and typhlitis (n=1)*
Small colon obstruction	6
Rectal impaction	6: *Positive finding of impaction of the rectum on rectal examination (n=5), meconium impaction (n=1)*
Grass sickness	13
Neoplasia	2
Parasitic	9
Peritonitis/ PUO	7: *Peritonitis (n=4), PUO (n=3)*
Enteritis/ colitis/ enterocolitis	13
Sand colic	14
Rupture of GI tract	4: L*arge colon (n=1), small colon (n=1), rectal (n=1), unrecorded (n=1)*
Non-GI causes	13: *Clinical signs of cardiac failure (n=1), choke (n=2), haematuria (n=1), hepatic disease diagnosed based on blood biochemistry(n=5), 'maggots in sheath', diagnosed on physical examination (n=2), urticarial/ allergic reaction (n=1), muscle abscess (n=1)*

4.3.4.2 Treatments administered

Treatment information was provided for 97.0% (985/1016) of cases. Most colic cases (77.1% (760/985)) were given more than one treatment (Table 23). Non-steroidal anti-inflammatory drugs (NSAIDs) were used in 86.9% (856/985) of cases. The most common types of NSAID were flunixin meglumine (41%, 351/856 of cases), metamizole, (30.6%, 262/856 cases) and phenylbutazone (30.5%, 261/856 cases). Hyoscine or hyoscine-containing combinations (Buscopan-20 or Buscopan Compositum) were administered in 67.6% (666/985) of cases. Opioids were administered in 11.1% (109/985) of cases, whilst sedatives were used in 33.5% (330/985). Oral fluids were given in 22.0% (217/985) of cases and laxatives were used in 6.7% (66/985) (Table 23).

Table 23. Treatments administered in 985 horses which received medical treatment in a prospective study of the primary assessment of abdominal pain presented to first opinion practitioners.

Treatment administered	**% of cases**	**Number of cases/ total number of horses treated**
Number of different treatments used		
One treatment combination	22.8	225/985
Two treatment combinations	41.9	413/985
Three treatment combinations	19.1	189/985
Four treatment combinations	11.5	113/985
Five treatment combinations	3.5	35/985
Six treatment combinations	0.8	8/985
Seven treatment combinations	0.2	2/985
NSAIDs	86.9	856/985
Flunixin meglumine	*41.0*	*351/856*
Metamizole	*30.6*	*262/856*
Phenylbutazone	*30.5*	*261/856*
Combination of two NSAIDs (including [1]Buscopan Compositum)	*9.8 (85.7)*	*84/856 (72/84)*
Combination of three NSAIDs	*0.6*	*6/856*
Other treatments		
Spasmolytics	*67.6*	*666/985*
Opioids	*11.1*	*109/985*
Sedatives	*33.5*	*330/985*
Oral fluids	*22.0*	*217/985*
Laxatives	*6.7*	*66/985*
Anthelmintics	*0.9*	*9/985*
Intravenous fluids	*1.7*	*17/985*
PTS/ [2]quinalbarbitone/cinchocaine	*0.6*	*6/985*
Other	*3.0*	*30/955*

[1] Boehringer Ingelheim, Bracknell, UK. [2]Somulose, Dechra Veterinary Products, Shrewsbury, UK. NSAIDs = Non-Steroidal Anti Inflammatory Drugs. PTS = Put To Sleep

4.3.5 Clinical features and diagnostic approach based on case outcome

The fifth objective of the work in this chapter was to identify clinical features which differed between non-critical and critical cases at the primary presentation. Critical and non-critical cases were extracted from the dataset. Non-critical cases were defined as cases exhibiting signs of gastro-intestinal pain at the time of the clinical examination which responded positively to simple medical treatment. This group therefore did not include cases which had resolved prior to examination or which required intensive hospitalised treatment. Critical cases were defined as all instances where the animal was hospitalised to receive critical care (either intensive medical treatment and/or surgical intervention) at any point during the single episode of colic, or where the animal died or was euthanased on humane grounds as a result of the condition.

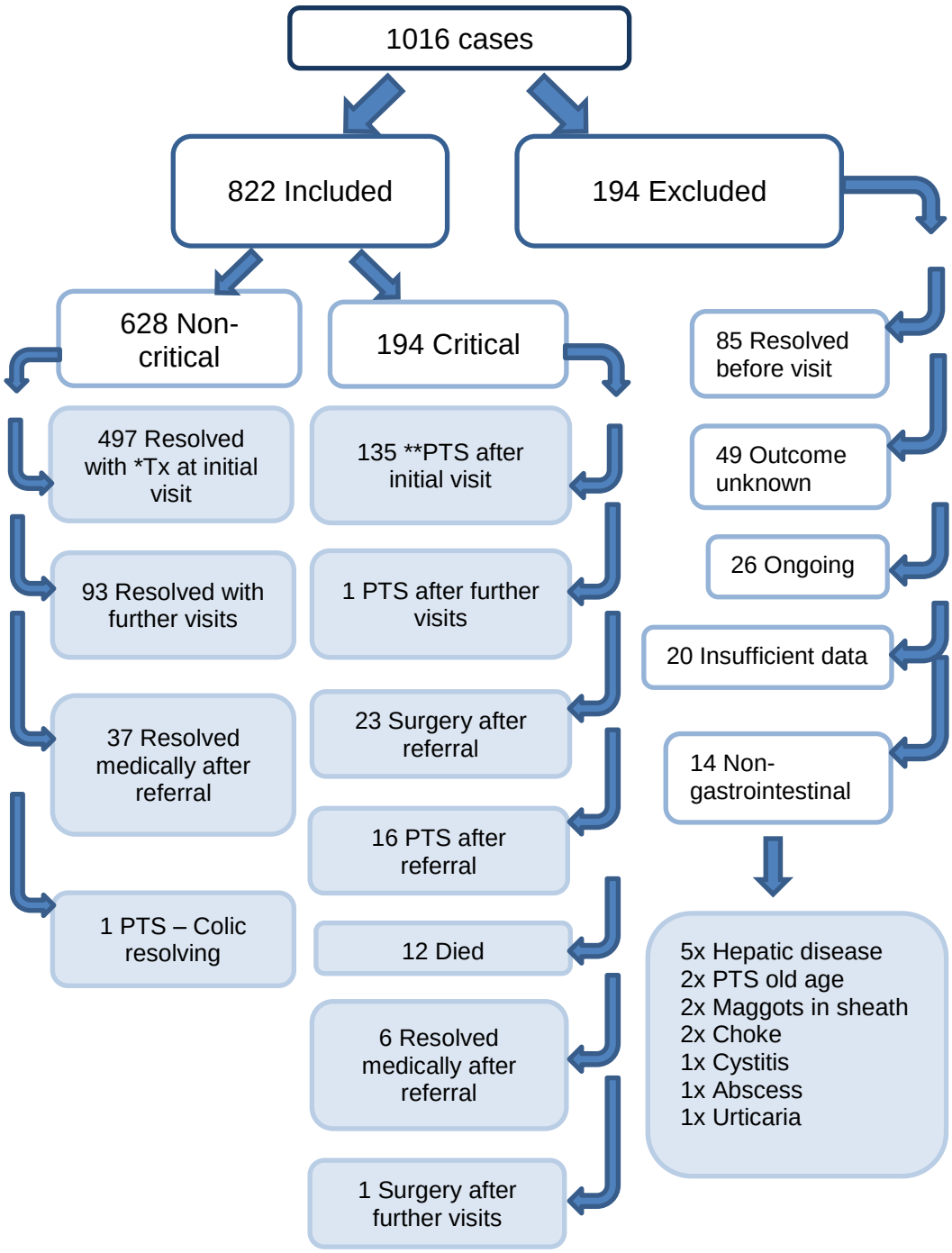
4.3.5.1 Case outcomes

One hundred and ninety four cases did not meet the inclusion criteria (19.1%, 194/1016) for either non-critical or critical cases. Removed cases consisted of 85 which resolved prior to the initial visit (43.8%, 85/194), 49 which were referred with outcome unknown (25.3%, 49/194), 26 which were described as ongoing with insufficient follow-up detail to allow them to be categorised (13.4%, 26/194), 20 cases which had insufficient or no data, diagnosis or outcome (10.3%, 20/194), and 14 cases with the cause of abdominal pain or death identified as of non-gastrointestinal origin (7.2%, 14/194). The latter 14 cases consisted of

five with hepatic disease, two euthanased due to old age, two horses with maggots in their sheath, two with choke, one case of cystitis, one abscess and one with urticarial (Figure 23).

The inclusion criteria was met by 822/1016 (80.9%) which were subject to further analysis; 628 were categorised as non-critical cases (76.4%, 628/822), and 194 were categorised as critical cases (23.6%, 194/822). Of the 628 non-critical cases, 497 resolved with treatment at initial visit (79.1%, 497/628), 93 resolved after further visits (14.8%, 93/628), 37 resolved medically after referral (5.9%, 37/628), and one case was euthanased for other reasons although the symptoms of abdominal pain were resolving (0.2%, 1/628).

Of the 194 critical cases, 135 were euthanased (69.6%, 135/194) following the initial visit, 1 was euthanased after further visits (0.5%, 1/194), 23 had surgery after referral from the first visit (11.9%, 23/194), 16 were euthanased after referral (8.2%, 16/194), 12 died (6.2%, 12/194), 6 resolved medically after referral for critical care (3.1%, 6/194) and one case was referred for surgery after further visits (0.5%, 1/194) (Figure 23).



*Tx = treatment, **PTS = Put To Sleep, euthanased.

Figure 23. Inclusion, exclusion and outcome of non-critical and critical cases of abdominal pain in 1016 horses.

Reasons for euthanasia were reported in 65 cases, and were categorised based on the veterinary practitioner's description as 'owner elected euthanasia' (n=15), 'owner unable to afford referral/surgery' (n=11), 'travel/ surgery not an option due to pain/ age' (n=7), 'no response to pain relief' (n=30), and 'ileal biopsy confirmed grass sickness' (n=2). Post mortem outcomes were only recorded in five of the 135 cases that were euthanased.

4.3.5.2 Clinical presentation and diagnostic approach

There were significant differences in the utilisation of diagnostic tests between cases with non-critical and critical outcomes. Rectal examination, nasogastric intubation, blood sampling and abdominal paracentesis were performed significantly ($p<0.05$) more frequently in cases with critical outcomes compared to those with non-critical outcomes (Table 24). Other diagnostic tests were performed in 48 non-critical cases and 22 critical cases. These were listed as faecal sand tests (performed in 15 non-critical and four critical cases), ultrasound examination (performed in 18 non-critical and 12 critical cases), faecal worm egg count or tapeworm ELISA (12 non-critical, four critical cases), dental examination (one non-critical case), *Streptococcus equi* antibody ELISA (one non-critical case), percussion of the abdominal wall (one non-critical case), histopathology (one critical case) and administration of phenylephrine eye drops (one critical case).

Table 24. Comparison of the use of diagnostic tests in 624 non-critical cases and 194 critical cases of equine abdominal pain.

	Non-Critical	**Critical**	**Significance**
Rectal Examination	72.7% (454/624)	83.9% (162/193)	p≤0.002
Nasogastric Intubation	34.0% (207/608)	47.9% (91/190)	p≤0.001
Blood Sample	16.3% (99/606)	22.8% (43/189)	p<0.05
Abdominal Paracentesis	5.7% (34/597)	15.2% (29/191)	p<0.0001

4.3.5.3 Univariable analysis of clinical variables associated with critical cases

The functional forms of the continuous variables were initially evaluated using GAM (generalised additive models) plots (Figure 24). These generalised linear models are an advanced form of a running average and show the value of the dependent variable along a single independent variable. This is then smoothed out using a curve which goes through as much of the data as possible. which demonstrated a linear functional relationship for each of the variables apart from weight. All variables with a LRTS of less than 0.2 were put forward into the multivariable model (n=35) (Table 25).

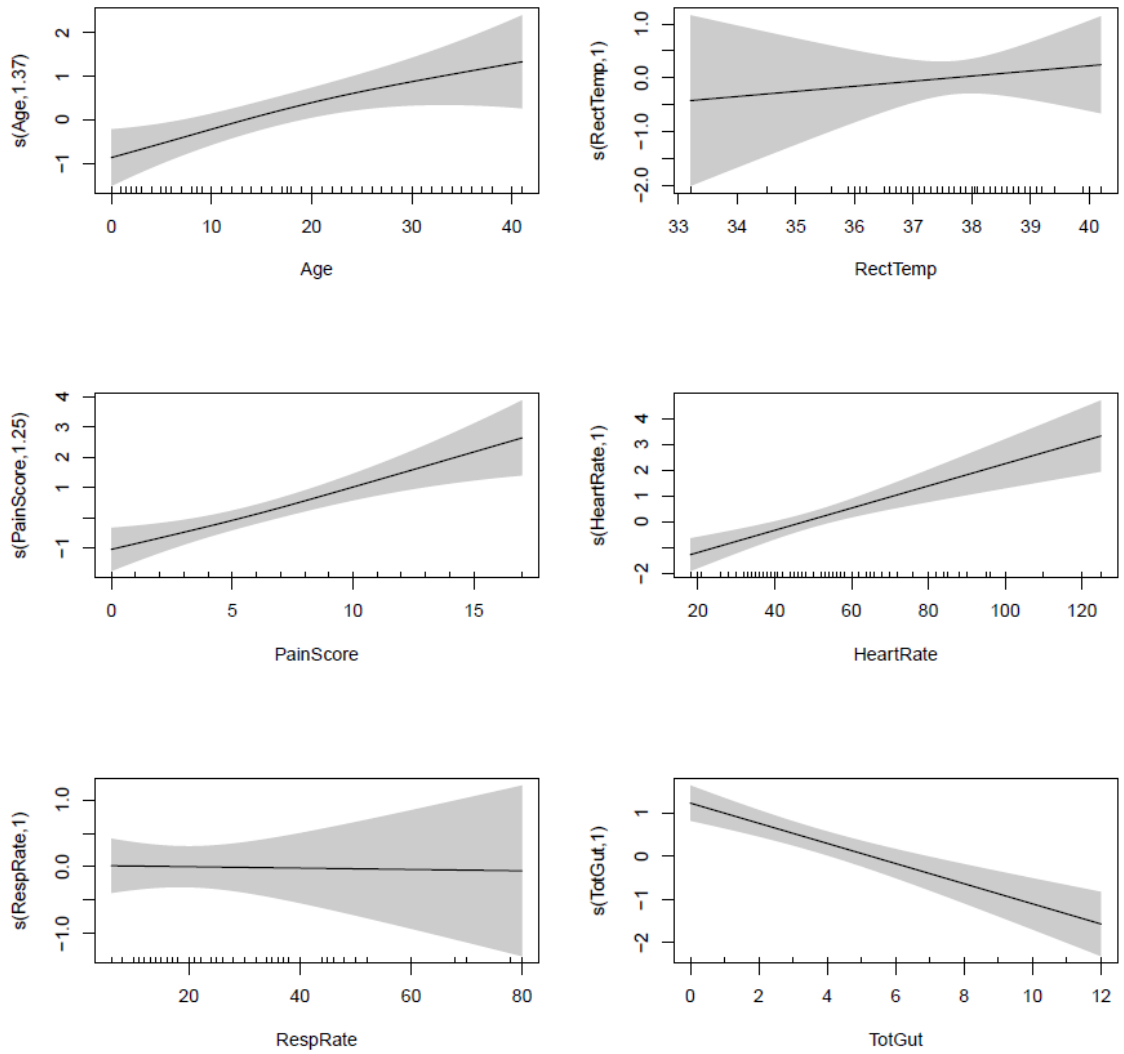


Figure 24. Generalised additive models (GAM) plots of continuous variables.

Table 25. Univariable analysis for clinical variables from 822 horses on the primary presentation to veterinary practitioners for clinical signs of abdominal pain; categorised as non-critical or critical on the basis of case outcome.

Variable		Coeff.	Exp(B)	95% CI	p value
Continuous					
	Age (years)	0.057	1.059	1.038-1.081	**<0.001**
	Estimated weight (kg)	-0.001	.999	0.998-1.000	0.247
	Combined pain score (max.17)	0.303	1.354	1.280-1.433	**<0.001**
	Heart rate (bpm)	0.077	1.080	1.066-1.095	**<0.001**
	Respiratory rate (brpm)	0.059	1.061	1.046-1.076	**<0.001**
	Rectal temperature	-0.198	0.820	0.642-1.048	**0.114**
	Total gut sounds	-0.381	0.683	0.639-0.730	**<0.001**
Categorical					
Breed	Pony	Ref			
	Arab/Arab x	0.414	1.513	0.963-2.376	**0.072**
	Cob	0.868	2.381	0.899-6.308	**0.081**
	Cross breed	0.806	2.239	1.359-3.689	**0.002**
	Warm blood/sports horse	-0.072	0.931	0.302-2.870	0.901
	Heavy type	0.226	1.254	0.767-2.049	0.368
	Thoroughbred (TB/TBx)	-0.711	0.491	0.110-2.194	0.352
Sex	Mare	Ref			
	Gelding	-0.091	0.913	0.656-1.270	0.588
	Stallion	-1.006	0.366	0.108-1.234	**0.105**
Body condition Score	Thin	Ref			
	Moderate	0.410	1.507	0.853-2.661	**0.158**
	Overweight	-0.122	0.885	0.557-1.406	0.604
Kicking	None	Ref.			
	Slight/occasional	0.107	1.113	0.759-1.633	0.583
	Moderate/frequent	0.975	2.650	1.645-4.269	**<0.001**
	Severe/continuous	2.388	10.886	2.828-41.91	**0.001**
Pawing	None	Ref.			
	Slight/occasional	-0.389	0.678	.0449-1.023	**0.064**
	Moderate/frequent	0.821	2.274	1.491-3.467	**<0.001**
	Severe/continuous	1.293	3.645	1.315-10.10	**0.013**
Sweating	None	Ref.			
	Slight/occasional	0.586	1.796	1.142-2.826	**0.011**
	Moderate/frequent	1.984	7.275	4.592-11.524	**<0.001**

	Severe/continuous	3.030	20.704	10.32-41.54	**<0.001**
Flank watching	None	Ref.			
	Slight/occasional	-0.278	0.757	0.498-1.152	**0.194**
	Moderate/frequent	0.817	2.264	1.452-3.532	**<0.001**
	Severe/continuous	2.133	8.437	2.491-28.58	**0.001**
Attempts to lie Down	None	Ref.			
	Slight/occasional	0.094	1.099	0.578-2.089	0.773
	Moderate/frequent	1.047	2.849	1.607-5.049	**<0.001**
	Severe/continuous	2.487	12.02	6.533-22.13	**<0.001**
Demeanour	Standing normally, BAR	Ref.			
	Lowered head	1.754	5.725	3.477-9.427	**<0.001**
	Twitching/agitated	1.990	7.318	4.697-11.40	**<0.001**
Absence of gut Sounds	No	Ref.			
	Yes	2.120	8.331	5.768-12.03	**<0.001**
Capillary refill Time	<2.5 seconds	Ref.			
	>2.5 seconds	2.782	16.14	8.973-29.04	**<0.001**
Mucous Membrane Colour	Pink	Ref.			
	Red	2.061	7.855	4.132-14.93	**<0.001**
	Cyanotic	4.869	130.1	17.58-964.1	**<0.001**
Pulse Character	Strong	Ref.			
	Weak	1.999	7.385	4.719-11.56	**<0.001**
Recent management Change	None	Ref.			
	Box rest	-1.721	0.179	0.042-.0766	**0.020**
	Increased stabling	-0.260	0.771	0.337-1.763	0.538
	Decreased exercise	-1.647	0.193	0.025-1.494	**0.115**
	Moved yards	-0.245	0.783	0.370-1.655	0.522
	Field change/turnout	-0.816	0.442	0.209-0.934	**0.032**
	Diet/bedding change	-0.334	0.716	0.377-1.357	0.306
	Weather	-0.756	0.470	0.134-1.649	0.238
	Other	-0.180	0.835	0.322-2.168	0.711
Recent faeces	Faeces passed in past six hours	Ref.			
	No faeces within last six hours	1.036	2.819	1.898-4.186	**<0.001**

Coeff. = Coefficient. Exp(B) = Exponentiation of the B coefficient (odds ratio). CI = Confidence Interval

4.3.5.4 Multivariable model of clinical variables associated with critical cases

The final multivariable model indicated five variables to be significantly associated with the likelihood of a case being classified as critical (Table 26). Although individual pain behavioural indices showed a high degree of association in the univariable analysis, the combined pain score resulted in the best model fit with an odds ratio (OR) of 1.19 for each unit increase in pain score ($p<0.001$). This odds ratio shows that a a higher pain score is 1.19 times more likely to be a critical case. The OR was calculated using the odds of interest for both critical and non-critical groups. Increasing heart rate was also associated with the likelihood of being critical ($p<0.001$) (Table 26). Three categorical variables were retained in the final model: capillary refill time >2.5 seconds ($p=0.046$), weak pulse character ($p=0.004$) and an absence of gut sounds in at least one quadrant ($p<0.001$) (Table 26).

Table 26. Multivariable model for clinical variables from 822 horses on the primary presentation to veterinary practitioners for clinical signs of abdominal pain; categorised as critical or non-critical on the basis of case outcome.

Variable		Coeff.	S.E.	OR	95% CI	p value
Combined pain score		0.17	0.04	1.18	1.08-1.29	<0.001
Heart rate (beats per minute)		0.05	0.01	1.05	1.03-1.08	<0.001
Capillary refill time	<2.5 seconds	Ref.				
	>2.5 seconds	1.16	0.37	3.21	1.02-10.09	0.046
Pulse character	Strong	Ref.				
	Weak	1.06	0.37	2.88	1.39-5.98	0.004
Absence of gut sounds	No	Ref.				
	Yes	1.29	0.28	3.65	2.08-6.40	<0.001

Coeff. = Coefficient. S.E. = Standard Error. OR = Odds Ratio. CI = Confidence Interval

4.4 Discussion

This is the first study to describe the demographics, presenting signs, clinical approaches used by veterinary practitioners, and outcome on the primary assessment of horses presenting with abdominal pain.

The methodology chosen for this work has both advantages and disadvantages. Involvement of different veterinary practitioners facilitated collection of a large data set, but also variation in case submission, and in approach to and interpretation of specific cases (Peabody *et al.*, 2004); however of course this is a real representation of what happens in veterinary practice. Engaging busy practitioners, who already have many demands on their time, was challenging, but the perspective, experiences and dilemmas faced by this large body of the veterinary profession is significantly underrepresented in the research literature (Graaf, 2005; Batchelor and McKeegan, 2012). Further qualitative research is required to explore the decision-making process behind the use (or not) of diagnostic tests (Everitt, 2011).

Participants were requested to submit data on cases seen, regardless of severity, but the numbers of cases reported varied significantly between different participants, and therefore may be subject to reporting bias. Potential biases may include selection of cases where the veterinary practitioner considered that they had achieved a good diagnosis or outcome, reporting of more severe cases of disease, or more challenging cases. The relatively high proportion of surgical/strangulating cases (17.5%) compared to other studies could suggest selection bias, however a similar proportion has been observed in practice records from two referral hospitals (current work as part of the Nottingham Colic Project,data not shown). This study also included a large proportion of undiagnosed cases (57.1%), as well as data from cases which had resolved prior to the veterinary practitioner attending,

and limited diagnostic work due to case presentation. This is in agreement with other work (Proudman, 1991; Mair and Mellor, 2005).

Recall bias in the form of misclassification is a potential hazard of collecting subjective information, particularly where there are numerous data collectors (Hassan, 2005). In the current study, this was reduced by the use of both open and closed questions (Ryan and Bernard, 2003; Krosnick and Presser, 2010). Responses from open questions identified themes and concepts which have not previously emerged about the variety and complexity of colic cases. Owner views and actions have been seen to impact heavily on decision-making, and the role of the owner in the primary assessment of colic requires further investigation, building on previous work on owner decision-making in recurrent colic by Scantlebury *et al.* (2011).

Information recorded by veterinary practitioners on history and signalment varied, with limited data collected in some cases. Responses to the section of the questionnaire on management and preventative healthcare showed that this information was not used by veterinary practitioners in decision-making in 25.4% of cases of abdominal pain (258/1016). Areas such as dental care, current feeding and riding management showed the lowest completion rates despite evidence suggesting an association with abdominal pain in the literature (Archer and Proudman, 2006; Scantlebury *et al.*, 2011). Pain and demeanour were assessed in all cases, highlighting the perceived importance associated with this aspect of the examination (Furr *et al.*,

1995). Basic assessments of cardiovascular indices and gastrointestinal sounds were performed in 98% of cases; exceptions were usually where the temperament of the horse or severity of signs precluded these assessments. Respiratory rate and rectal temperature were assessed less frequently (89.4% and 81.4% respectively), which most likely reflects the greater significance of pain and cardiovascular indices in decision-making in equine abdominal pain (Furr *et al.*, 1995; Proudman *et al.*, 2006).

Following rudimentary physical assessment, rectal examination was the most commonly used diagnostic test (73.8% of cases). It was perhaps surprising that it was not used in specific cases, including suspected impactions, and suspected surgical lesions where the horse was subsequently euthanased. However, primary assessments are often made in conditions with limited facilities and therefore there may be reasonable considerations against its use in some situations (Southwood and Fehr, 2012). The second most common diagnostic test was nasogastric intubation (35.6% of cases); this was often associated with administration of oral fluids, and therefore its use may have been diagnostic, therapeutic or both. Other diagnostic tests were used infrequently during the first assessment of cases, but these often resulted in positive findings, which may reflect their selection in cases with strongly indicative clinical features.

There was marked variation in veterinary practitioner's approaches and the tests used in both critical and non-critical cases. As discussed

previously, more evidence is required on how different tests contribute to decision-making, why veterinarians preferentially use tests in some cases and not in others, and the influence of factors such as cost, condition of the horse, facilities, and owner wishes.

There are also many factors which influence choice of treatments in cases of abdominal pain, and therefore this study does not draw conclusions about the efficacy of different treatments, but instead provides evidence of what is currently being used. There were a large variety of different treatments, and most cases received more than one pharmacological type. A number of drugs, such as sedatives, opioids, and spasmolytics, facilitate diagnostic tests, and therefore may be used for restraint/diagnosis, rather than having a purely therapeutic role (Mair and Edwards, 1998; Mair and Mellor, 2005). NSAIDs were the most commonly used treatment; flunixin in particular, which probably reflects current evidence on its analgesic and anti-inflammatory properties compared to phenylbutazone (Keegan *et al.*, 2008; Sanchez and Robertson, 2014; Cook and Blikslager, 2015).

Spasmolytics (hyoscine) were given in a large number of cases (646 cases), but this may reflect its use to facilitate rectal examination rather than just as a treatment, as its use exceeded the numbers of cases categorised as either spasmodic or gas colic (322 cases) (Sundra *et al.*, 2012). Oral fluid therapy was used more frequently than intravenous fluid therapy, and there are a number of possible reasons, including the stage of the disease, cost, and current evidence on oral vs intravenous

fluids for intestinal impactions (Hallowell, 2008). This study illustrated the use of a range of different specific treatments and combinations.. Further research is required to determine which treatments are most effective in the primary treatment of cases.

There are many potentially confounding factors which can influence decision-making including veterinary practitioner opinion, client preference, finance constraints, and facilities (Everitt, 2011). Therefore multivariable analysis focused on clinical features of the horse rather than diagnostic approach and treatments used. Cases were categorised critical *vs* non-critical as this was considered most appropriate for a primary care setting. Most previous studies are based on referral populations, and have categorised cases as medical/surgical or on the basis of survival/death outcomes (Furr *et al.*, 1995; Thoefner *et al.*, 2001; Van der Linden *et al.*, 2003). This does not allow comparison with mild cases seen in a primary care setting, and excludes a proportion of the population for whom referral or surgery is not an option. In this study, only 23.7% (46/194) of the critical cases were referred for surgery or medical treatment, and only 12.4% (24/194) horses had surgery; the majority of the critical cases were euthanased in the primary practice setting (69.6%, 135/194).

The variables that remained in the final statistical model as significantly associated with critical cases (higher heart rate, increased pain/behaviour scores, reduced gastrointestinal sounds and simple indicators of hypovolaemia or shock) are similar to those identified as

prognostic indicators in studies from referral hospital population (Reeves *et al.*, 1989a; Proudman *et al.*, 2005; Nielsen, 2007; Sutton *et al.*, 2009). Communication of these features of critical cases to owners and veterinary practitioners is important in order to improve patient care.

Scoring systems for behavioural assessments of pain associated with colic have been previously described (Ashley *et al.*, 2005) and include individual behaviours such as rolling (Thoefner *et al.*, 2003), flank gestures or kicking (Pritchett *et al.*, 2003). This study found that all six of the pain/behaviour assessments (kicking, pawing, sweating, flank-watching, attempts to lie down and demeanour) were significant in the univariable model, but the total sum of all six scores was most predictive in the final model. The present study provides further evidence on the severity of pain/behaviour in identifying critical cases, and also highlights that this is also of value in the early presentation of cases.

Heart rate has been consistently associated with the severity of abdominal pain and mortality (Furr *et al.*, 1995), and identified as a useful prognostic indicator of survival (Puotunen-Reinert, 1986; Reeves *et al.*, 1989a; Thoefner *et al.*, 2001; Van der Linden *et al.*, 2003; Ihler *et al.*, 2004; Proudman *et al.*, 2006). The use of heart rate as a prognostic indicator for surgery is less well documented; it was omitted from a multivariable logistic regression model by Reeves *et al.,*(Reeves *et al.*, 1992) despite being used in the death/survival model in the same study.

Other indices found to be significant in predicting outcome of equine colic include packed cell volume (PCV) (Ihler *et al.*, 2004), total protein (TP) albumin (Grosche *et al.*, 2006) and peritoneal lactate concentration (Van den Boom *et al.*, 2010) all of which were rarely utilised at the primary examinations in this study. This present study shows that changes in cardiovascular indices may predict critical cases even at the primary presentation of the case. Further research is required to how early these cases are being identified by owners, and how this impacts on clinical signs.

Gastrointestinal sounds were also retained in the final model. Absence or decrease in intestinal sounds was significantly associated with survival (Grulke *et al.*, 2001) or the need for surgery (Parry *et al.*, 1983; White *et al.*, 2005). The final model had absence of gut sounds within one quadrant and this was more predictive than was an overall decrease in the total score gut sounds across all four quadrants. This suggests a localised absence of borborygmi may be an early indicator of severe gastrointestinal disease.

This study illustrated the variation in presentation of cases of abdominal pain to veterinary practitioners. Clinical signs in cases seen at referral hospitals might be expected to be more advanced from those seen at initial evaluation, due to the time elapsed and therefore progression of pathology. There were a number of cases in the present study which had severe clinical parameters comparable with levels found on admission to hospital, consistent with relatively advanced pathology.

The severe nature of these cases highlights some of the challenges faced by primary care practitioners, and identifies a potential requirement for improved owner education on recognising and seeking assistance for horses with abdominal pain. The number of horses included in the critical group that died of colic (n=12) or were euthanased at the primary evaluation (n=136) presents a potential welfare concern. More research is needed to investigate the possible reasons behind this, including how owners are recognising abdominal pain and deciding to seek veterinary assistance, and the impact of duration of colic on clinical signs and outcome.

Supporting decision-making in the primary assessment of abdominal pain with guidance about diagnosing critical cases could help reduce unnecessary delay in important ethical decisions about cases with a poor outcome. Adopting ‘red flag’ protocols for the diagnosis of critical cases of colic is a recommended course of action (Sobri *et al.*, 2003; Downie *et al.*, 2013) (Figure 25).

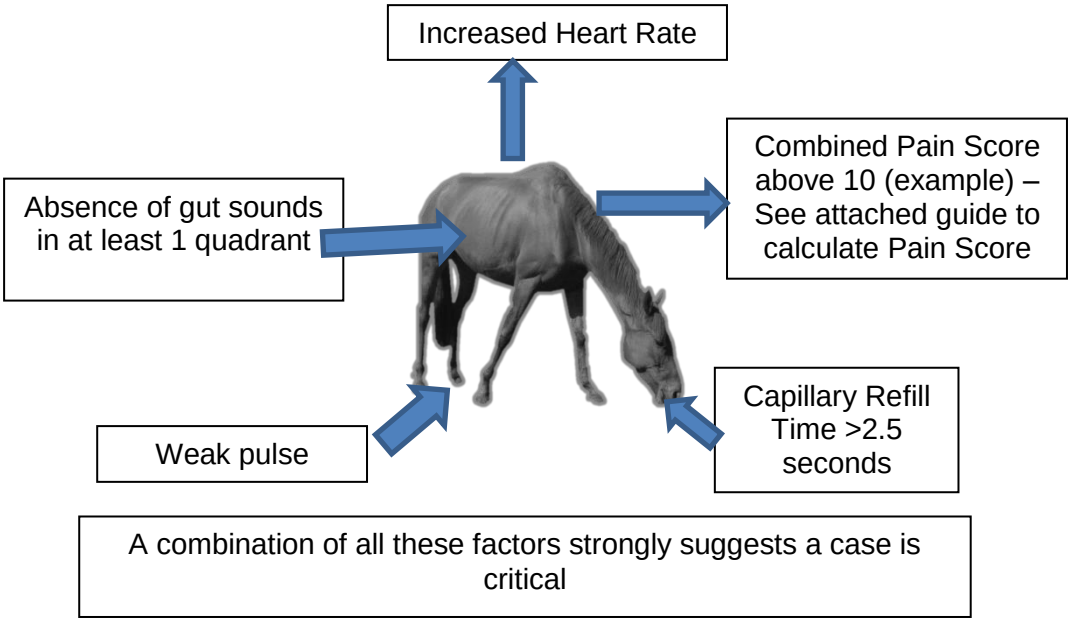


Figure 25. A rudimentary example of a red flag clinical signs card to support veterinary practitioners in the differentiation of critical cases of colic using results of multivariable analysis

4.4.1 Recommendations for future work

1) An investigation into motivators and de-motivators influencing veterinary practitioners' selection of diagnostic tests in first-opinion colic to further understand the decision-making process and perceived value of diagnostic tests.
2) Collaboration across a large number of veterinary practices to encourage shared practice and develop a database of colic cases as suggested by Mair (2009). A prospective cohort study of primary cases of colic would be a potential long-term outcome of this.
3) The role of the owner in the primary assessment of abdominal pain needs investigation. Engaging owners in the recognition and

diagnosis of colic cases will impact on the time to referral for suspected critical cases.

4) Development of evidence-based support for veterinary practitioners in the differentiation of critical cases from non-critical. Guidance could take the form of a red flag clinical signs card (Sobri *et al.*, 2003; Downie *et al.*, 2013).

4.5 Conclusion

This is the first published study presenting primary assessment data on abdominal pain in the horse, and information about current general practice. There are still substantial gaps in the evidence relating to primary veterinary care of horses with abdominal pain, but this study is an initial step in gathering evidence and identifying areas for future research. The variation in practice in terms of the ranges of severity and outcome, and also some of the challenges in diagnosis that practitioners face warrants further study.

This is the first study comparing critical and non-critical cases of abdominal pain on primary presentation to the veterinary practitioner. Behavioural manifestation of pain, heart rate and gastrointestinal borborygmi are important clinical parameters in the triage of critical cases, and should be considered essential aspects of primary examination (Greenhalgh, 1997).

The questionnaire for this survey was designed and in pilot phase before the start of this thesis, and so apart from minor alterations, LC was not involved in the development of this document. M. Curran and T. Bayes undertook pilot survey design and data collection under the supervision of J. Burford and S. Freeman. From the preparation and implementation of the main survey launch, LC was the main researcher with responsibility for press and marketing, data collection, all communication with practices, data sorting and analysis. J. Burford designed the survey website and email and this was maintained by both J. Burford and L. Curtis. Support was available from G. England, J. Burford and S. Freeman who also contributed to study design, data collection and study execution.

CHAPTER FIVE: Survey of veterinary practitioners' opinions of diagnostic tests used in the primary evaluation of equine abdominal pain

This chapter aims to meet the following objective: To generate evidence on how cases of equine abdominal pain present at the initial evaluation by veterinary practitioners, the diagnostic approaches and treatments currently used, and the factors which influence clinician decision-making

5.1 Introduction

Abdominal pain (colic) is of high welfare and economic concern (Traub-Dargatz *et al.*, 2001; Egenvall *et al.*, 2008), and has been ranked as the most important emergency problem by both owners and veterinary surgeons (Traub-Dargatz *et al.*, 1991a; Bowden *et al.*, 2014). Abdominal pain has many different aetiologies and therefore assessment of the underlying cause can be challenging (Dukti and White, 2009). An early and accurate diagnosis is particularly important for critical cases, where the degree, duration and severity of pathology will impact upon outcome (Proudman *et al.*, 2002a).

There are many diagnostic tests used to evaluate horses with abdominal pain. These vary in their cost, and the facilities and level of expertise required to perform the techniques, and interpret outcomes. Research on diagnostic tests for horses with abdominal disease is focused on referral hospital populations (as detailed in the systematic

review in Chapter Three). There is limited evidence on diagnostic approach at the first evaluation of cases, with most based only on opinion, published as reviews and textbooks (Greatorex, 1972; Wilson and Gordon, 1987a; Archer, 2004; Southwood and Fehr, 2012). The primary evaluation of cases of abdominal pain is usually an emergency consultation in the field environment, often with limited facilities and there may also be financial restrictions on the owner. Factors, such as temperament of the horse, and portability and cost of diagnostic equipment may therefore have a significant impact on decision-making.

The aims of this survey were to describe veterinary practitioners' opinions of diagnostic tests used in the primary assessment of abdominal pain in horses, and to determine which factors affect their diagnostic approach and choice of tests. As in Chapter Three, the term 'diagnostic test' follows the definition set by Bossuyt *et al.* (2003):

"Any method for obtaining additional information on a patient's health status. This includes laboratory tests, imaging tests, function tests, pathology, history and physical examination."

The study objectives were:

- To determine the perceived value of tests veterinary practitioners use in their initial diagnostic approach to equine abdominal pain.
- To identify the factors which influence veterinary practitioner's choice of diagnostic tests for abdominal pain.

5.2 Methodology

This project was reviewed and approved by the Ethics Committee, School of Veterinary Medicine and Science, University of Nottingham.

5.2.1 Survey distribution

A questionnaire was developed to survey UK equine veterinary practitioner's opinions of diagnostic tests for equine abdominal pain (Appendix K). Questionnaires were distributed by email and by post to all equine veterinary practices that were listed in the RCVS Directory of Veterinary Practices 2010 (n=850) which was also used for the study in Chapter 4. Individuals who were registered with the colic survey in Chapter 4 were also contacted using the weekly email reminder.

The questionnaire was sent in paper format which could be completed and returned, alternatively an online version was also developed and the link included on the postal communication and sent by email to those already registered with the colic survey in Chapter 4 (Adobe Forms Central, Adobe Systems, CA, USA). The online version of the survey was open from 17th October-15th November 2013. Postal questionnaires were distributed on 28th-30th October 2013. A follow up email reminder was sent to all potential participants shortly before closure of the survey.

5.2.2 Questionnaire design

A full copy of the online questionnaire can be found in Appendix K. The questionnaire included a consent form which was a requirement for participation, consistent with current guidelines (Data Protection Act, 1998; B.S.A., 2002; B.E.R.A., 2011). The questionnaire consisted of both open and closed questions, and was organised into three main sections. Section One related to the demographics (number of years qualified, confidence of practitioner, type of employment, further qualifications). This section also collected information about the type of practice where participants worked (categorised into mixed (any combination of species), equine first opinion and/or second opinion, equine referral, and other), experience of the practitioner and the estimated number of cases of abdominal pain examined by the respondent each month.

Section Two related to the importance of diagnostic assessments according to veterinary practitioners. This focused on six diagnostic tests (rectal palpation, abdominal paracentesis, nasogastric intubation, haematology and biochemistry, ultrasonography, and response to analgesia/ treatment), based on the findings of the prospective survey of the primary evaluation of cases of abdominal pain (Chapter Four), and a review of the current literature (White and Edwards, 1999; Singer and Smith, 2002; Archer, 2004). Participants were asked to rank these six diagnostic tests in order of importance. They were also asked to

provide information on any other diagnostic tests that they either used or wished to use.

Section Three investigated how practitioners used tests within their diagnostic approach. This included the estimated proportion of cases in which they selected each of the six tests, the scenarios in which they would use each test, and their reasons for not using diagnostic tests (including the main primary reason and up to two other reasons why they would not use a diagnostic test). This third section on diagnostic approach primarily focused on the six diagnostic tests from Section Two, but also gave respondents the option to include any further tests they personally used. Descriptions of when respondents would use each test were not restricted by word count, and were free text answer boxes. Respondents were also asked to select the reasons why they would not use a test from a list of possible options, based on current and published literature (Gough and Munroe, 1998; Archer, 2004; Everitt, 2011), but were also given a free text option to identify 'other' reasons for their choice.

5.2.3 Data analysis

Data were exported from the online response portal (Adobe Forms Central, Adobe Systems, CA, USA), or input manually for postal forms, into a spreadsheet (Excel 2010, Microsoft Corporation, WA, USA). Descriptive data analyses, including mean, mode and range values, were displayed in graphs and tables. Free text responses (total of 26

open questions within the questionnaire), were reviewed and categorised, and ranked in order of frequency for different themes. The reasons why practitioners did not use each diagnostic test were analysed to determine both the primary reason for not using the test (how frequently each reason was ranked first by respondents), and the total frequency for each reason (total number of times each reason was given, irrespective of ranking; respondents could list up to three reasons for each test).

5.3 Results

A link to the online version of the questionnaire was emailed to 943 veterinary practitioners, and 112 of these questionnaires were completed (response rate of 11.9%). Paper-based versions of the questionnaire were posted to 985 practitioners/practices, and 136 of these were completed and returned, producing an overall total of 248 responses. Fifteen postal respondents did not complete the ethics statement section, and five respondents were not based in the UK. These responses were excluded; therefore 228 responses were used for analysis. There were several respondent errors within the paper-based questionnaires; these included a number of respondents placing multiple tests under one ranking, and some sections remaining incomplete. This resulted in the exclusion of data from some ranked questions and the total number of responses is given for each question.

5.3.1 Participant demographics and experience

The majority (55.7%) of veterinary surgeons worked in mixed practice (127/228 responses), 22.8% worked in first opinion equine practice (52/228), 17.9% in first and second opinion equine practice (41/228), 3.1% in referral only (7/228), and 0.44% (1/228) in 'other' employment (equine charity work). The number of years since graduation for each participant ranged from 0 to 47, with a median of 9 and a mean value of 14.0 +/- 12.0 years (n=226 responses). The mean number of colic cases that participants stated that they saw was 5.00 +/- 4.36 (mean +/- SD) cases per month, with a range of 0 to 30 (n= 216 responses).

When asked to rate their confidence when assessing a case of colic (0 - not confident to 5 - very confident), 48.2% (105/218 of participants) rated their confidence level as 4, and 99.5% of respondents rated their confidence level between 2 and 5 (217/218) (Figure 26). The estimated frequency of use of rectal examination, abdominal paracentesis, blood sampling, nasogastric intubation, abdominal ultrasonography and response to analgesia by veterinary practitioners working in different types of practice is shown in Figures 27a-f.

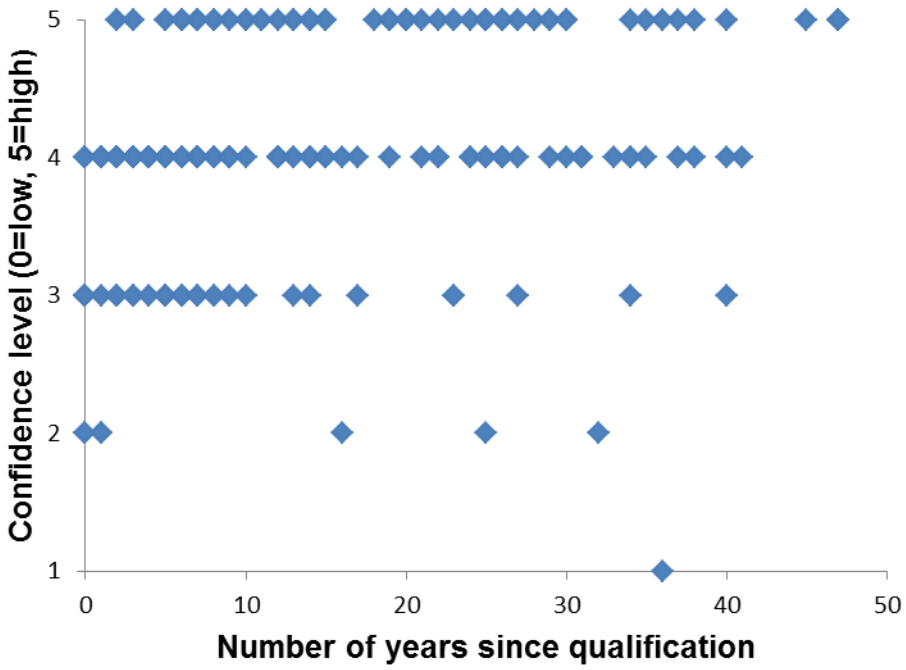
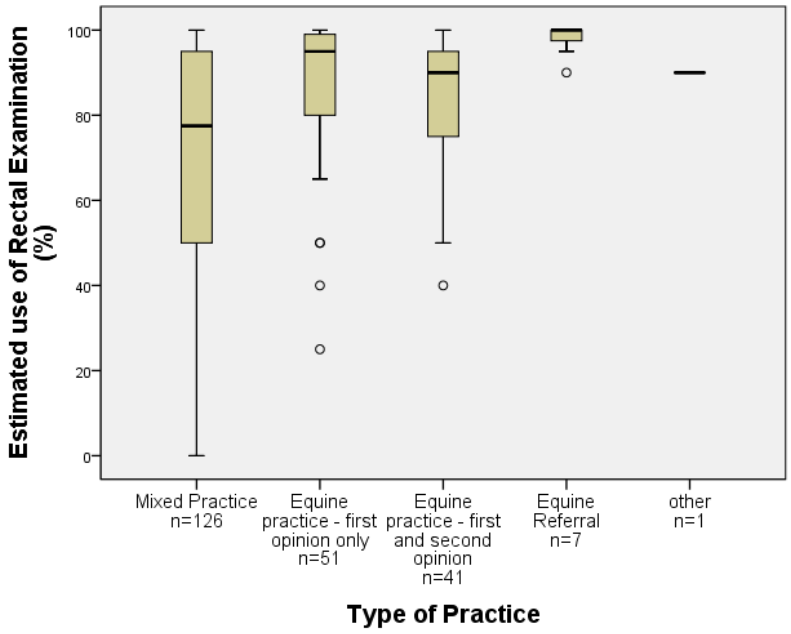
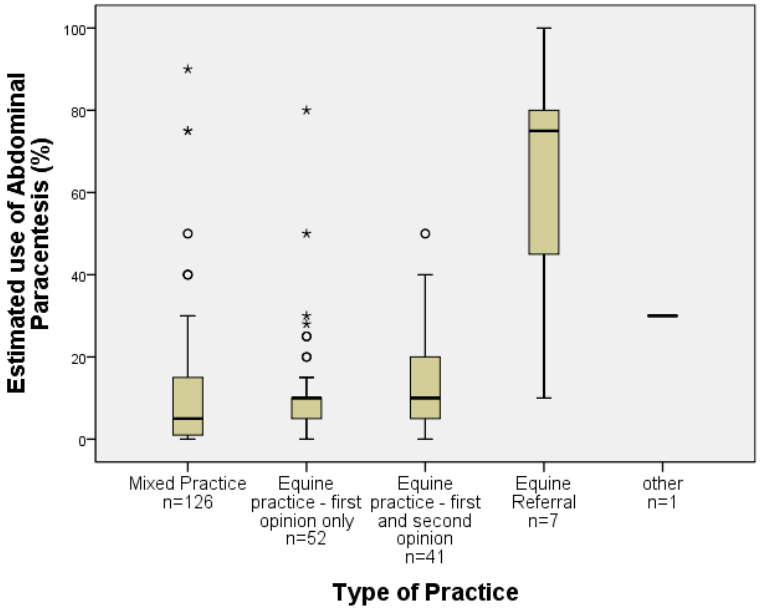


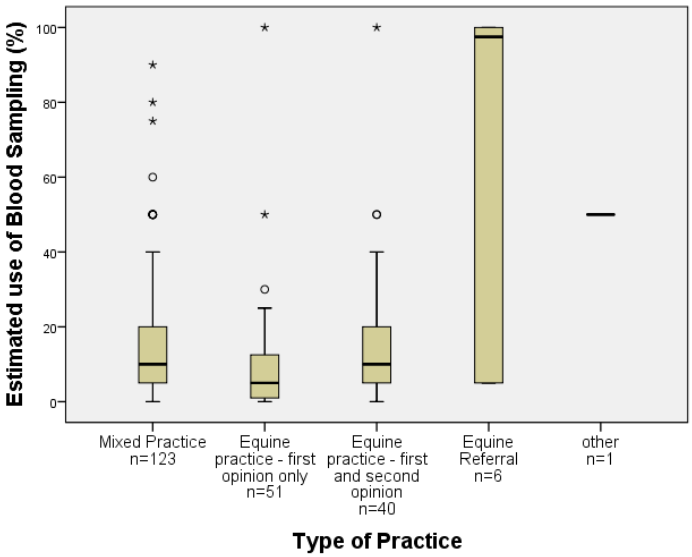
Figure 26. Confidence ratings and years since qualification from a survey of 228 UK veterinary practitioners of diagnostic tests for horses with abdominal pain.



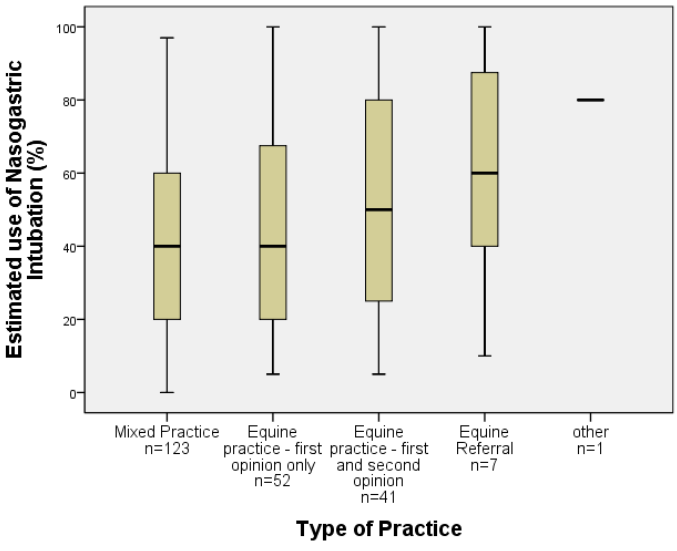
(a)


Estimated use of Abdominal Paracentesis (%)
100
80
60
40
20
0
Mixed Practice n=126
Equine practice - first opinion only n=52
Equine practice - first and second opinion n=41
Equine Referral n=7
other n=1
Type of Practice

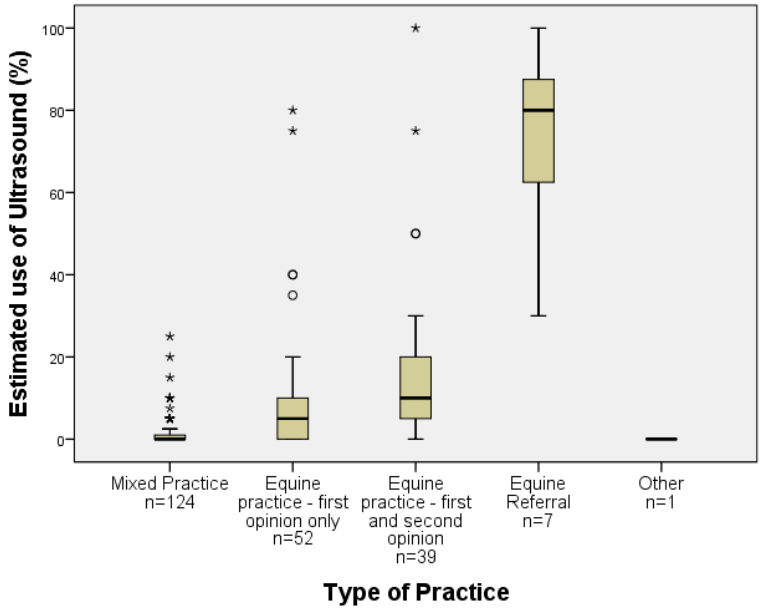
(b)


Estimated use of Blood Sampling (%)
100
80
60
40
20
0
Mixed Practice n=123
Equine practice - first opinion only n=51
Equine practice - first and second opinion n=40
Equine Referral n=6
other n=1
Type of Practice

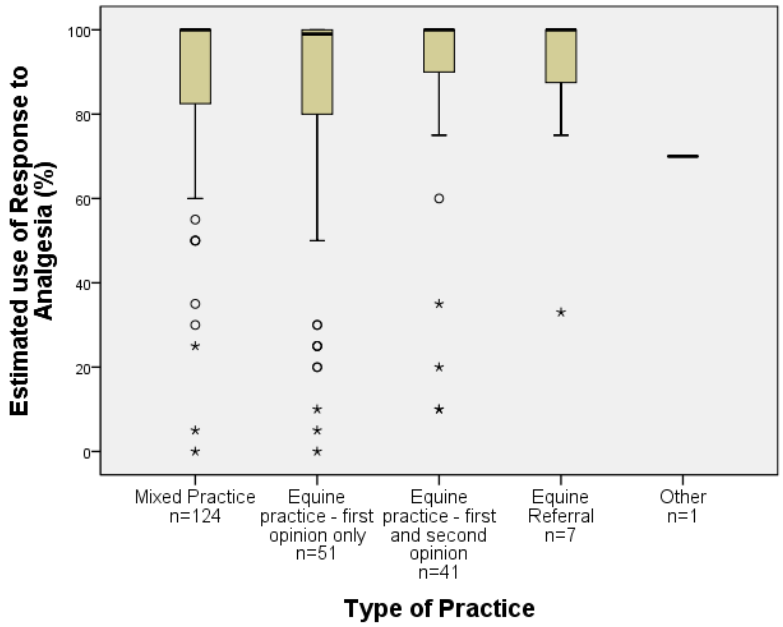
(c)


Estimated use of Nasogastric Intubation (%)
100
80
60
40
20
0
Mixed Practice n=123
Equine practice - first opinion only n=52
Equine practice - first and second opinion n=41
Equine Referral n=7
other n=1
Type of Practice

(d)



(e)



(f)

Figure 27a-f. Estimated frequency of use of (a) rectal examination, (b) abdominal paracentesis, (c) blood sampling, (d) nasogastric intubation, (e) abdominal ultrasonography and (f) response to analgesia in horses presented with clinical signs of abdominal pain by veterinary practitioners working in different types of practice, from a questionnaire of 228 UK veterinary practitioners.

5.3.2 Perceived value of diagnostic tests according to veterinary practitioners

The first objective of this study was to determine the perceived value of tests veterinary practitioners use in their initial diagnostic approach to equine abdominal pain.

There were 174 valid responses for the ranking of six diagnostic tests in order of importance. Fifty four responses were excluded due to ranking of multiple tests at the same level of importance. Rectal examination was identified as the most important diagnostic test (47.7%, 83/174), followed by response to analgesia (45.4%, 79/174), ultrasound (2.9%, 5/174), nasogastric intubation (1.75%, 3/174), blood sampling (1.1%, 2/174) and abdominal paracentesis (1.1%, 2/174).When asked to rank the least important diagnostic tests, veterinary practitioners identified ultrasound (43.9%, 76/174), blood sampling (35.6%, 62/174), abdominal paracentesis (10.9%, 19/174), rectal examination (3.4%, 6/174), nasogastric intubation (2.9%, 5/174) and response to analgesia (2.9%, 5/174).

One hundred and twenty-three participants described other diagnostic tests that they used to evaluate cases of abdominal pain; 69.1% (85/123) identified physical/clinical examination including a full physical examination and individual components such as auscultation, behaviour/pain and cardiovascular parameters, 9.8% (12/123) identified peritoneal/blood biochemistry including lactate or serum amyloid A, 6.5% (8/123) faecal egg counts, 4.1% (5/123), enzyme-linked

immunosorbent assay for *Anoplocephala* antibody, 3.3% (4/123) phenylephrine eye drops, 3.3% (4/123) faecal sedimentation (sand) test, 2.4% (3/123) exploratory laparotomy and 1.6% (2/123) of respondents listed radiography.

Respondents were also asked to identify any tests that they were not currently using but that they considered would be valuable in the assessment of a case. Sixty nine participants gave responses to this question, and of these, 36.2% (25/69) identified ultrasound examination, 29.0% (20/69) blood and peritoneal lactate, 17.4% (12/69) haematology/biochemistry, 8.7% (6/69) abdominal paracentesis, 4.3% (3/69) exploratory laparotomy, laparoscopy and/or gastroscopy, 1.4% (1/63) biopsy and 1.4% (1/63) of respondents listed history taking of management changes.

Participants indicated that they used (rather than considered most important which was covered in the previous section) response to analgesia/treatment most frequently in cases of abdominal pain, followed by rectal examination, nasogastric intubation, haematology and biochemistry, abdominal paracentesis, and ultrasound (Table 27). Individual practitioners' use of different diagnostic tests varied markedly; for all six tests, there were individual respondents who indicated that they used these tests in 0% and 100% of cases (Table 27).

1.3.3 Factors influencing the selection of diagnostic tests

The second objective for this study was to identify the factors which influenced veterinary practitioner's choice of diagnostic tests for abdominal pain.

The free text responses of the scenario in which practitioners found each test most useful were categorised by themes. This identified that both rectal examination and ultrasound were considered most useful to identify lesion or case type, abdominal paracentesis was considered most useful to differentiate 'medical vs surgical' or to determine prognosis, nasogastric intubation most useful for suspected 'proximal' intestinal lesions, haematology/biochemistry most useful for recurrent/chronic cases, and response to analgesia was considered most useful in most cases (Table 27).

When asked why they would not use specific diagnostic tests, veterinary practitioners identified 'test not required to contribute to diagnosis/treatment' as the main primary reason for all six diagnostic tests (Table 27). When the total frequency of all the reasons was analysed (primary reason and up to two other reasons from each respondent), the most commonly identified reason varied between the diagnostic tests. 'Test not required to contribute to diagnosis/treatment' remained the most frequently identified reason for abdominal paracentesis, nasogastric intubation, haematology and biochemistry, and response to analgesia, but 'risk to personal safety' was the most commonly identified reason for not using rectal examination, and 'lack

of facilities/resources' was the most commonly identified reason for not using ultrasound (Table 27). 'Other' reasons for not performing rectal examination were identified in 47/478 reasons identified (each respondent could identify up to three reasons), and included horses that were too small to permit rectal examination. Lack of personal experience in the technique was identified as a reason for not performing ultrasound in 18.0% (76/423) of reasons identified). Additionally, 16 participants identified ultrasound examination as the test they would like to perform but currently do not because of a lack of facilities and/or sufficient knowledge.

One hundred and ninety six respondents gave free text information stating that they used 'other' diagnostic tests more frequently than the six listed in the questionnaire. A total of 52 different tests were listed by 42 respondents, and the main tests identified were clinical examination (63.5%) and faecal analysis (13.5%).

Table 27. Estimated use of different diagnostic tests in horses with abdominal pain, and reasons they would not use specific tests, from a survey of UK practitioners.

	Estimated % use of diagnostic test (Mean+/-SD (range))	Scenario in which test is considered to be most useful	Primary reason for not performing test (% frequency of responses)	Top three reasons for not performing diagnostic test (% of summed responses)
Rectal examination	75.9 +/- 21.2 (range 0-100)	Identification of specific lesion or case type (including differentiating medical vs surgical)	Test not required to contribute to diagnosis/treatment (32.9%, 56/270)	1.Risk to personal safety (27.0%, 129/478) 2.Poor cooperation from horse (23.8%, 114/478) 3. Test not required to contribute to diagnosis/treatment (19.5%, 93/478)
Abdominal paracentesis	13.5 +/- 17.8 (range 0-100)	Diagnosis/prognosis of medical vs surgical/severe cases of colic/decision for euthanasia	Test not required to contribute to diagnosis/treatment (65.9%, 116/176)	1. Test not required to contribute to diagnosis/treatment (30.6%, 144/471) 2. Lack of facilities/resources (16.1%, 76/471) 3. Poor cooperation from horse (13.6%, 64/471)
Nasogastric intubation	43.9 +/- 27.6 (range 0-100)	Diagnosis of cases with suspected proximal lesion (oesophageal/gastric or small intestinal)	Test not required to contribute to diagnosis/treatment (69.9%, 121/173)	1. Test not required to contribute to diagnosis/treatment (32.8%, 151/459) 2. Poor cooperation from horse (28.3%, 130/459) 3. Risk to personal safety (11.5%, 53/459)

	Estimated % use of diagnostic test (Mean+/-SD (range))	Scenario in which test is considered to be most useful	Primary reason for not performing test (% frequency of responses)	Top 3 reasons for not performing diagnostic test (% of summed responses)
Haematology and biochemistry	15.2 +/- 20.6 (range 0-100)	Diagnosis of recurrent colic/ongoing cases	Test not required to contribute to diagnosis/treatment (63.6%, 110/173)	1. Test not required to contribute to diagnosis/treatment (34.9%, 153/439) 2. Financial situation of owner (33.0%, 145/439) 3. Lack of facilities/resources (14.1%, 62/439)
Ultrasound	8.0 +/- 18.1 (range 0-100)	Identification of specific lesion or case type (including differentiating medical vs surgical)	Test not required to contribute to diagnosis/treatment (44.0%, 74/168)	1. Lack of facilities/resources (27.2%, 115/423) 2. Test not required to contribute to diagnosis/treatment (25.3%, 107/423) 3. Financial situation of owner (21.5%, 91/423)
Response to analgesia/ treatment	87.2 +/- 24.0 (range 0-100)	All/most scenarios	Test not required to contribute to diagnosis/treatment (49.5%, 50/161)	1. Test not required to contribute to diagnosis/treatment (32.4%, 66/204) 2. Owner preference (18.1%, 37/204) 3. Financial situation of owner (14.7%, 30/204)

5.4 Discussion

In clinical practice, the decisions made by veterinary practitioners in apparently similar scenarios may be substantially different, but this variation is influenced by many factors (Everitt, 2011). Factors identified in previous studies are the age and experience of the veterinary practitioner, the actual and perceived value of the test, the risks to the animal and veterinary practitioner, cost of the test, and owner preference (Kassirer, 1976; Gough and Munroe, 1998; Lucas *et al.*, 2009; Vandeweerd *et al.*, 2012b). This study highlighted that veterinary practitioners use a small number of key diagnostic tests (response to analgesia, rectal examination and nasogastric intubation) in horses presenting with abdominal pain, and other tests are used infrequently. In the free text responses, several veterinary practitioners highlighted the importance of the findings of the clinical examination on decision-making and that they considered this an important diagnostic test. It is a limitation of this methodology that the role of the physical examination was not given more clarity, or used to generate views on how veterinary practitioners used the physical examination in their decision-making.

Although a number of factors were identified as reasons not to use a diagnostic test, the primary reason veterinary practitioners might chose not to use the six tests was if they did not consider the tests were required to contribute to diagnosis. This, again, underlies the perceived importance of clinical examination and the key tests. A number of other reasons were identified, many of which are particularly relevant to the

primary assessment of patients; the lack of facilities, resources and finances, and the risk associated with some procedures. The perceived risk to the animal of tests including rectal examination, nasogastric intubation and abdominal paracentesis warrants further investigation.

This study had a relatively low response rate. Response rates of veterinary practitioners can be variable, with published rates varying between 20-50% (Nielsen *et al.*, 2006; Roberts and Murray, 2013). The total response rate was not calculated for this study, as the postal questionnaires were circulated to practices as well as individuals, and therefore the total recipient population is unknown. A low response rate may introduce bias into a study, and the outcomes of the study should be interpreted with this in mind (Templeton *et al.*, 1997). Potential biases are: increased participation by practitioners with an interest in clinical research or evidence-based medicine, or by those who are outliers within the population. Outliers may include both ranges of spectrum; from veterinary practitioners who see many cases and consider themselves to have a high level of expertise, to those who are inexperienced, have low confidence levels, or who have had a negative experience. The latter group may be more likely to associate stress and high risk with the evaluation of cases of abdominal pain. An ideal study design would follow up on non-responders to determine whether their demographics and opinions were similar to the respondents in the current study, and use repeated follow up to improve response rates (Edwards *et al.*, 2002). A recent survey by BEVA achieved good response rates (B.E.V.A., 2014), but it was conducted by the main

equine organisation, and the study design included personal requests to delegates attending a conference (BEVA Congress 2013) which will have improved response rates, but introduced considerable bias towards conference attendees.

In this study, there were completion issues with the paper-based version, including failure to complete the consent section, and multiple ranking of single response questions which resulted in exclusion of a number of paper forms. This was not an issue with the online forms, where logic rules were applied to ensure that participants completed the forms in the expected format. Overall there were a number of possible sources of bias in this study, and this could have been reduced by more clarity on the paper-based forms to explain how to complete the ranking questions, and more follow up of non-respondents. The choice to rank multiple diagnostic tests is important as it shows that veterinary practitioners place equal value on some tests. It also highlights that the decision-making process for abdominal pain incorporates a combination diagnostic test findings.

Despite the low numbers of veterinary surgeons who participated, the study did represent a range of types of practice and experience of participants. Over 50% of the veterinary practitioners worked in mixed practice, with only a small percentage (3.1%) in referral hospital situations, and the survey included a range of experience from new graduates to practitioners who had been qualified for many years (maximum 47 years). The estimated number of colic cases seen per

month showed a significant range from 0-30 cases. Despite this, confidence levels of the practitioners was high, with the majority (48.2%) rating their confidence as 4/5. Factors that affect confidence level may include the duration of time since qualifying (Vandeweerd *et al.*, 2012b), gender of participants (Lundeberg *et al.*, 1994), and the number of cases seen (Roberts and Murray, 2013).

There was an association between confidence and clinical experience, however this was not restricted to older practitioners and a number of recently qualified veterinary surgeons also placed themselves at the higher end of the confidence scale. It could be suggested that there was bias towards more confident veterinary practitioners willing to complete the questionnaire; however this could not be measured. The role of confidence has not previously been investigated in relation to the diagnosis of abdominal pain in the horse. The present study has highlighted that confidence levels when negotiating a primary case of colic are not simply reliant on length of experience. Training may be needed to resolve confidence issues, and guidance could be beneficial to support decision-making in diagnostic approach to abdominal pain for some veterinary practitioners.

The most common diagnostic test - other than the six tests listed in the questionnaire - identified by most respondents was clinical examination (63.5%). This finding confirms that the six diagnostic tests included within the study are those predominantly used in practice, and emphasises the importance veterinary practitioners place on a clinical

exam as part of their decision making process (Southwood, 2012). Its inclusion in the questionnaire as a diagnostic test can be debated; a clinical examination is assumed to be undertaken in every case of abdominal pain, but this study highlights role of the clinical examination in the veterinary practitioner decision-making process of cases of abdominal pain.

Rectal examination was ranked as the most important diagnostic test in the evaluation of abdominal pain, in agreement with previous statements by Robinson and Sprayberry (2009) and White and Edwards (1999). Despite this, it was only used in an estimated 75.9% of cases and there was a wide variation in its estimated use, with participants describing its use in a range of 0-100% of cases). Recall bias is always a potential confounding factor in questionnaires of opinions (cross-sectional study design) (Mann, 2003), and therefore the present study represents practitioners' opinions rather than accurate case percentages. However, the estimated use of rectal examination in this survey (75.9% of cases) is very similar to the actual number of cases (73.8%) in which rectal examination was used in the prospective survey (Chapter Four). It would therefore be reasonable to conclude based on these two studies that rectal examination is used by practitioners in approximately 75% of primary assessments of equine abdominal pain.

The wide variation in use of rectal examination between different individuals (0-100% of cases) reflects the variation in clinical practice,

as identified in Chapter Four. One factor that may contribute to this is concerns over safety. Within this study, risk to personal safety and poor cooperation of the horse were commonly identified reasons for not performing a rectal examination. This reflects the challenges of the field setting for the examination of many cases, and the greater risk of injury to practitioners working in equine practice (Reijula *et al.*, 2003; B.E.V.A., 2014). Patient cooperation and temperament were also found to influence the decision making process in small animals by Everitt (2011) and this factor is likely to be more influential when dealing with large animals. This study has highlighted the value veterinary practitioners place on the rectal examination. More detailed qualitative investigation is warranted to further understand the demotivators for the use of diagnostic tests, especially rectal examination. This could help generate targeted professional development to increase skill and confidence.

This study was conducted to investigate the variation in practice highlighted in the colic survey in Chapter Four. Despite the small scale of this questionnaire, and the possible biases inherent in a survey of opinions, findings on the use of diagnostic tests are similar to those from the prospective case study in Chapter Four. Practitioners estimated that they used blood samples (for haematology and/or biochemistry) as a diagnostic test in approximately 15% of cases in this current survey, compared to its actual use in 18.1% of cases in the case series presented in Chapter Four. The use of other tests was slightly higher in the current survey, but show similar trends to the

aforementioned case series (Chapter Four). Practitioners estimated that they used nasogastric intubation in around 40% of cases in this survey, compared to its use in 35.6% of cases in the study in Chapter Four, abdominal paracentesis use was estimated in around 13% of cases, compared to 7.3% in this study, and ultrasound use was estimated in around 8% of cases, compared to use in 3.4% of cases in the prospective case series (Chapter Four). Both studies identify rectal examination as the most commonly used diagnostic test, followed by nasogastric intubation and blood sampling, with abdominal paracentesis and ultrasound being used less frequently on the primary examination. These are considered by veterinary practitioners to be key tests in the diagnosis of colic. More work is needed to understand the value of other tests; why they are/are not selected and which types of case they are useful for. Further collaboration with practice is needed to supplement research evidence with the practical implications with the long-term outcome of evidence-base guidance in the diagnostic approach to abdominal pain.

The diagnostic test that was considered least important on the primary examination in this survey was ultrasound examination. There is some evidentiary support for the value of ultrasound as a diagnostic tool; it is suggested to demonstrate increased sensitivity in detecting specific conditions compared to rectal palpation (Klohnen *et al.*, 1996; Slack, 2012). Lack of facilities/resources and finance of the owner were identified as two of the three main limiting factors which prevent veterinary practitioners from performing ultrasound. In addition 18% of

responses identified lack of personal experience as a limiting factor, and 16 participants identified ultrasound examination as the test they would like to perform but do not because of a lack of facilities and/or sufficient training. This demonstrates that there are issues around availability, cost and training which may currently limit the practical use of ultrasound in cases of abdominal pain. These factors are acknowledged in a referral population by le Jeune and Whitcomb (2014) amongst other limitations including patient preparation, horse-to-horse variation and the complexity of the abdominal pain. It is possible that abdominal ultrasonography is considered more useful in referral hospitals than in primary practice.

The financial situation of the owner was highlighted as an important factor when deciding whether to use haematology and biochemistry, ultrasound examination and response to analgesia/treatment. Financial situation was also identified as an influential factor in the decision making process in Everitt (2011); there are concerns within the equine veterinary profession about the impact of the current financial climate on owner decision-making and treatment options for equine abdominal pain (Lindegaard *et al.*, 2011; Blikslager and Mair, 2014).

There is currently very little research on veterinary practitioner's decision making. This study has shown many similarities between small animal and equine practice, and identified some of the factors that practitioners considered to be most important. The impact of different factors on decision-making in equine abdominal pain warrants further

investigation through a larger scale survey and through qualitative studies, such as workshops, focus groups, case vignettes and interviews. These would enable the issues identified in this study to be clarified and strategies to be developed to improve or resolve main limiting factors.

5.4.1 Recommendation for future work

1) More qualitative studies are needed to investigate the complex nature of veterinary practitioner decision-making in the primary assessment of abdominal pain in the horse. One suggestion is to incorporate case vignettes from Chapter Four to investigate variation in approach; comparing desired approach of each participant with the action actually taken in the original case. This method could help develop a training scheme to improve practitioner confidence through discussion about real cases.

5.5 Conclusion

This is the first published study to describe motivations and demotivators behind the selection of diagnostic tests used by veterinary practitioners in the primary assessment of equine abdominal pain. Substantial variation between individual practitioners' approaches was highlighted, consistent with other findings in this thesis, which has allowed further interpretation of those findings and provided justification for the current study. The role of confidence in practitioner approach

may contribute to this variation, and is a factor not previously investigated in relation to diagnostic approach to equine abdominal pain. Along with confidence, this survey has identified that there are barriers to the recruitment of certain diagnostic tests such as training and safety concerns, and therefore a need for evidence to support and justify their use.

Evidence to support commonly used diagnostic tests in equine abdominal pain is lacking as shown in Chapter Three; more research is needed to support evidence-based veterinary decision-making. Focused research in diagnostic tests is needed for veterinary practitioners to make evidence-based decisions when approaching a case of abdominal pain. Improvements to the current study design including questionnaire alterations, more respondents and feedback from non-respondents would have enhanced the quality of the results and reduced susceptibility to bias of this study; however this is initial investigation and can help inform future research. Increasing the evidence base in diagnostic tests which veterinary practitioners predominantly use in addition to those which lack sufficient research would help develop strategies for supporting decision-making.

This study was initially carried out as a veterinary student's (I. Trewin) third year project which L. Curtis assisted in the supervision of along with S. Freeman and J. Burford. L. Curtis provided supervisory support during the design and implementation of the questionnaire. Following

completion of the student project, L. Curtis continued to collect an additional 44 questionnaires, made alterations to the data analysis and re-analysed the entire dataset. The write up of the chapter was entirely original with no similarity to the project work carried out by I. Trewin. The questionnaire and project was based on L. Curtis' survey of colic cases (Chapter Four). L. Curtis was therefore directly involved in assisting and supervising I. Trewin through EndNote training, statistics/SPSS lessons and general advice. Any statistical analysis carried out by I. Trwein was checked and amended by L.Curtis. The revised work is included in this chapter. I. Trewin's contribution must be acknowledged as follows; questionnaire design, survey distribution and data recording. In addition to general support and advice, G. England, J. Burford and S. Freeman contributed to study design, data collection and study execution.

CHAPTER SIX: Multi-disciplinary workshops on recognising and diagnosing abdominal pain in the horse

This chapter meets the following objective: To develop a methodology for multi-disciplinary workshops, to discuss and generate evidence-based statements on the recognition and diagnosis of abdominal pain in the horse.

6.1 Introduction

Early diagnosis and rapid referral are integral contributors to a positive outcome in cases of abdominal pain (colic) in horses and ponies requiring surgical intervention (Fischer, 1997; Ramey, 2008). At present there is limited consistent evidence-based advice for both veterinary practitioners and horse owners about the recognition and diagnostic approach to acute abdominal pain. Some research has been undertaken to recognise current veterinary practice and understand the primary assessment of cases of abdominal pain (Chapter Four, Mair and Mellor (2005)). This project has investigated potential barriers to the recruitment of diagnostic tests (Chapter Five) and undertaken systematic reviews of the existing literature on risk factors, and diagnostic tests used for colic (Chapters Two and Three). There is also some research on horse owners and carers opinions, to investigate their understanding, interpretations and decision-making with regards to equine abdominal pain (Bowden *et al.*, 2014; Scantlebury *et al.*, 2014).

This research has started to provide evidence to support decision-making for veterinary practitioners and horse owners and carers. Decision-making is complex however, and in practice, there are often limitations to the employment of evidence-based strategies which arise from the literature (Vandeweerd *et al.*, 2012a).

Chapters Four and Five have highlighted the variation in veterinary surgeons' approaches and the influence of owner views and opinions, financial restraints, personal safety concerns and other barriers which are not necessarily addressed in the published literature. Pleasure horse owners, equine charities, elite sport horse owners/ trainers and livery yard owners all have different priorities when deciding how to address the health needs of their animal (Scantlebury *et al.*, 2014). Many stakeholders also may not have access to scientific literature about potential complications and prognosis due to subscription charges and marketing towards veterinary professionals by the journal. Open Access publications are however becoming more common, and hopefully this will encourage non-veterinary interest in up-to-date research and aid their decision-making. There is a plethora of horse advice websites for owners and carers; some are backed with scientific evidence (for example www.thehorse.com), whilst others appear to be anecdotal, and often they require some understanding of how they should be interpreted and implemented. Conditions which rarely affect UK horses, such as sand colic or the risks associated with Bermuda grass hay may be discussed on non-UK websites (Hudson *et al.*, 2001). Choosing a trustworthy website can be challenging for many owners

and can lead to confusion about conflicting advice. There are useful charity and voluntary organisation websites with independent advice, such as the Blue Cross and the British Horse Society (B.H.S., 2014; Blue Cross, 2015), but there are many more sources of information which have commercial links.

More interaction is needed between the veterinary profession and equine stakeholders (especially horse owners) to communicate recent developments in research. The opportunity for different stakeholders to discuss accepted approaches, and consolidate views and opinions on diagnostic approaches to equine abdominal pain is also important. The importance of health care professional working together with patients is recognised as an important aspect of optimising human health care (Simpson *et al.*, 1991; Stevenson *et al.*, 2000; Hall and Weaver, 2001). This approach is particularly important for equine colic, where veterinary practitioners need to work together with stakeholders to ensure critical cases are recognised early and timely decisions are made for the mutual benefit of the horse.

Effective collaboration and development of evidence-based agreements (often called evidence-based statements) can be achieved through multi-disciplinary workshops. The Children's Brain Tumour Research Centre based at University of Nottingham used multi-disciplinary workshops in the initial stages of developing supportive evidence-based statements, which were then used to develop guidelines for clinicians in the "identification, assessment and investigation of children who may

have a brain tumour" (Wilne *et al.*, 2010). A similar approach using a 'consensus conference' as a platform to present and circulate evidence whilst group meetings were held to generate or build consensus on clinical statements has also been used in other fields (Weller *et al.*, 2012; Walker *et al.*, 2013). In veterinary medicine, multi-disciplinary workshops have been used by The Veterinary Vaccination Network and Cattle Health and Welfare Group for research collaboration and discussions about emerging issues and the current state of the industry (C.H.A.W.G., 2015; Vetvaccnet, 2015).

This chapter proposes the concept of developing multidisciplinary stakeholder workshops to develop evidence-based statements on the recognition and diagnosis of abdominal pain in the horse. The multi-disciplinary nature of such workshops will ensure that any statements generated are likely to have wide relevance and realistic potential impact on the health and welfare of the horse. The workshops will act as a step towards encouraging better communication between the veterinary profession and other equine stakeholders including horse owners, charities and organisations invested in the horse. Consensus statements can be developed incorporating evidence from systematic reviews of the literature (Chapters Two and Three) with a prospective study of equine abdominal pain (Chapter Four). These would then combine with professional expertise in the form of multidisciplinary workshops and (in the longer term) allow via a subsequent Delphi process consensus statements to be produced (Wilne *et al.*, 2010; Frewer *et al.*, 2011).

Workshops were therefore planned to help horse owners/carers, other stakeholders and veterinary professionals to work together to improve the recognition and diagnosis of equine abdominal pain. In order to encourage equal coverage of the main focuses of the workshop, they were divided in to two events. Workshop One was focused on the recognition of colic. Workshop Two was focused on the diagnosis of colic. The term colic was preferentially used as it is more commonly used and understood by non-veterinary individuals.

6.1.1 Objectives of multi-disciplinary Workshop One

It was planned to undertake multidisciplinary discussions in small groups bringing together personal knowledge, experience and research evidence with the aim of meeting the following objectives:

- To generate statements on common clinical signs of colic in the horse.
- To generate statements identifying which clinical signs are associated with critical cases.
- To generate a list of important information for a veterinary practitioner to collect on initial examination of colic.

6.1.2 Objectives of multi-disciplinary Workshop Two

It was planned to undertake multidisciplinary discussions in small groups bringing together personal knowledge, experience and research evidence with the aim of meeting the following objectives:

- To generate statements describing the physical examination approach to the first assessment of a horse with colic.
- To generate statements describing the diagnostic approach to the first assessment of a horse with colic.
- To identify where further education/training/research is required to support decision-making in the first assessment of colic.

6.2 Methodology

Previous studies that have conducted workshops to generate statements as part of a Delphi process have inferred the importance of the initial exploratory workshop but have not discussed the methodology of the sessions in detail (Wilne *et al.*, 2010; Frewer *et al.*, 2011). The design and implementation of the multi-disciplnary workshops of this study are of original design unless specific details are otherwise referenced.

6.2.1 Participant recruitment

Participants were recruited from a database of veterinary practitioners contributing to the Nottingham Colic Survey investigated in Chapter Four (which spanned mixed practice, first opinion and referral equine practice). In addition to an email invitation, veterinary practitioners were also sent a newsletter at the end of the colic survey which provided information about the workshops and invited potential participants to

take part (Appendix I). Practice type and clinician experience details were already recorded for these participants.

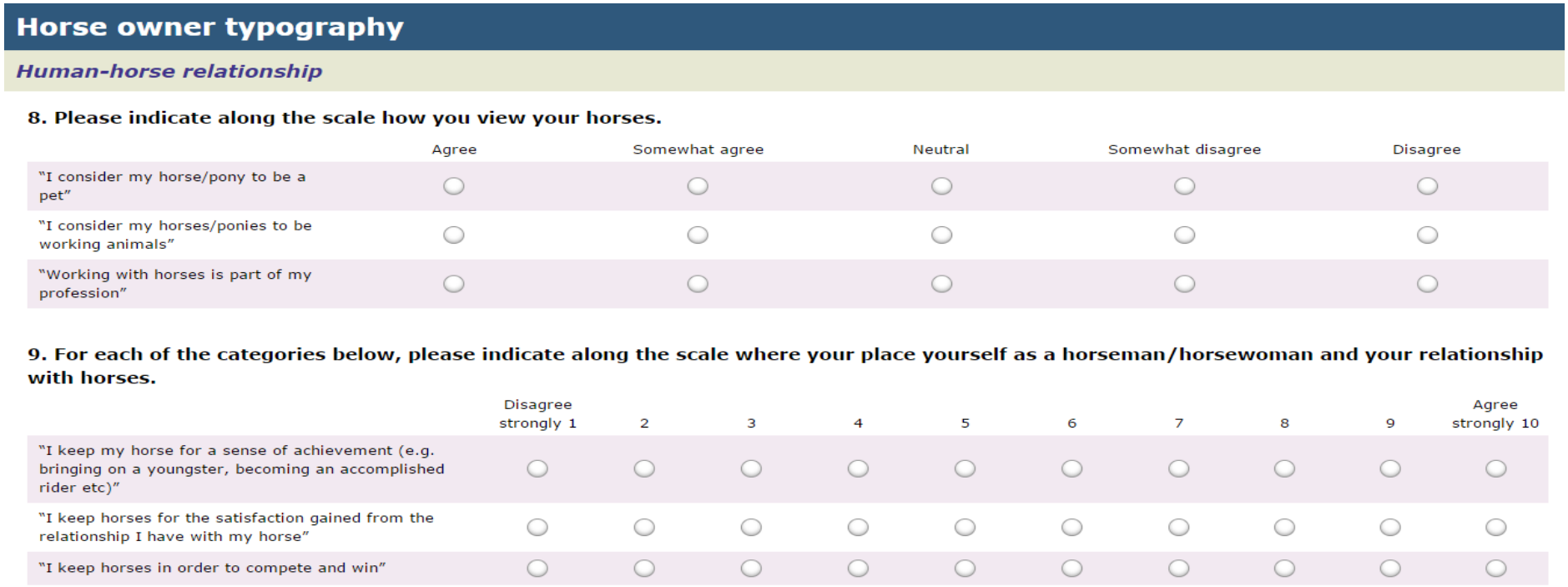
Equine veterinary specialists, practitioners, UK equine charities and professional organisations (including British Equine Veterinary Association (BEVA), British Equestrian Federation (BEF), British Horse Society (BHS) and RCVS Trust) were invited during an annual meeting of the National Equine Welfare Council (NEWC). Additional participants were identified through personal communication using a convenience sampling approach. Professionals who read the Veterinary Record publication were also targeted for the second workshop through a three page report of the first workshop (Freeman and Curtis, 2015).

Horse owners were sought with a range of different experiences through verbal communication with local or participating veterinary practices, at local horse events, through social media (Nottingham Colic Project Facebook and Twitter accounts), and using 1061 contacts from a separate owner survey (Bowden *et al.*, 2014). An online questionnaire was given or linked to all methods of communication, a copy of which can be found in Appendix L.

The online questionnaire included a consent section followed by general demographic data which was used to categorise owners according to age, geographical location and number of colic cases experienced. A range of 'types' of owner was required to represent a variety of views and human-horse relationships, and so a method of categorising owners was adapted from that used by Scantlebury *et al.*

(2014). Figure 28 shows the online questionnaire page used to identify the human-horse relationship of each respondent. Six owner typographic categories were previously identified using cluster analysis by Scantlebury *et al.* (2014). The owners in the present study were grouped into the same categories using a rudimentary visual examination of responses and fitting the respondent with the closest fitting typography using definitions from Scantlebury *et al.* (2014) (Appendix M). An example of this is shown in Figure 29. The six typographies were Competing Professional, All-Round Amateur, Non-Competing Professional, Friend/Companion, and Competing Amateur.

The responses from owners who stated their availability for each workshop were placed into a separate file and sorted into categories primarily by typography, then by number of colic cases experienced and then by age group. Where possible, a varied selection of ages and experiences were chosen within each type. Owners were contacted by email and invited to attend Workshop One or Workshop Two.



Horse owner typography

Human-horse relationship

8. Please indicate along the scale how you view your horses.

	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree
"I consider my horse/pony to be a pet"	○	○	○	○	○
"I consider my horses/ponies to be working animals"	○	○	○	○	○
"Working with horses is part of my profession"	○	○	○	○	○

9. For each of the categories below, please indicate along the scale where your place yourself as a horseman/horsewoman and your relationship with horses.

	Disagree strongly 1	2	3	4	5	6	7	8	9	Agree strongly 10
"I keep my horse for a sense of achievement (e.g. bringing on a youngster, becoming an accomplished rider etc)"	○	○	○	○	○	○	○	○	○	○
"I keep horses for the satisfaction gained from the relationship I have with my horse"	○	○	○	○	○	○	○	○	○	○
"I keep horses in order to compete and win"	○	○	○	○	○	○	○	○	○	○

Figure 28. One web page from an online survey used to recruit horse owners for multidisciplinary colic workshops, and to group owners by typography using a method established by Scantlebury et al. (2014).

‘Competing Professional’: “Competing professionals predominantly saw their horses as working animals. This group reported a sense of achievement and satisfaction from their relationship with their horse, and competing and winning was often quite important to them. Many, but not all, felt their horse was also a pet”.

8. Please indicate along the scale how you view your horses.

	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree
"I consider my horse/pony to be a pet"	○	○	○	☑	○
"I consider my horses/ponies to be working animals"	☑	○	○	○	○
"Working with horses is part of my profession"	☑	○	○	○	○

9. For each of the categories below, please indicate along the scale where your place yourself as a horseman/horsewoman and your relationship with horses.

	Disagree strongly 1	2	3	4	5	6	7	8	9	Agree strongly 10
"I keep my horse for a sense of achievement (e.g. bringing on a youngster, becoming an accomplished rider etc)"	○	○	○	○	○	○	○	○	☑	○
"I keep horses for the satisfaction gained from the relationship I have with my horse"	○	○	○	○	○	○	○	☑	○	○
"I keep horses in order to compete and win"	○	○	○	○	○	○	○	○	○	☑

Figure 29. Scantlebury et al. (2014) definition of ‘Competing Professional’ and example of an online questionnaire response that was assessed to meet these criteria.

6.2.2 Preparation for the multi-disciplinary workshops

Speakers were invited who had carried out research that could provide supportive evidence for the recognition and/or diagnosis of acute abdominal pain (colic). Studies carried out within the University of Nottingham Colic Project were also combined to build evidence for the workshops. An 'evidence pack' was developed and distributed to all accepted participants to each workshop in advance of the event. The evidence pack for Workshop One consisted of a set of five evidence booklets; one contained general information, and the remaining four booklets were the evidence available to support the workshop (including abstracts and full text publications). The evidence pack for Workshop Two consisted of a single booklet. The first booklet from Workshop One and the single booklet from Workshop Two both contained the following contents:

- Directions to the event, timetable of the day and contact details
- An overview of the workshop/Delphi process
- Details of the day, aims and objectives of the workshop
- Research team details, including visiting speakers
- Advice on how to prepare for the workshop
- A brief overview of critical reading and interpreting evidence
- A question and answer guide for horse owners/ carers of the workshops
- Abstracts and full articles of presentations (Workshop One)
- Abstracts of presentations (Workshop Two)

Also included in both evidence packs was a consent form and travel expenses form (Appendix N). The evidence pack from workshop two can be found in Appendix O.

6.2.3 Execution of the multi-disciplinary workshops

The format for each workshop was as follows: following a welcome upon arrival (refreshments and tour of the veterinary school), participants were given introductory talks about the research team and aims of the project. Presentations were then delivered in plenary sessions by the colic project research team in addition to invited speakers which gave the attendees an overview of the current evidence.

Workshop groups of approximately six participants were formulated in advance for group discussions. It was intended that each group within Workshop One would include a veterinary practitioner involved in first opinion/general practice work, a veterinary practitioner involved in specialist/ referral work, a stakeholder representing any equine organisation, an experienced (had seen more than 11 cases of colic) horse owner, and a less experienced (had seen less than 11 cases) horse owner of differing typographies. It was intended that each group within Workshop Two would include a veterinary practitioner involved in mixed practice work, a practitioner involved in first opinion equine work, a practitioner involved in specialist/referral work, a stakeholder representing any equine organisation and an experienced (had seen

more than 11 cases of colic) horse owner of any typography, as long as there was a range across the whole workshop. Each group additionally had a note taker (fourth or fifth year veterinary medicine student) and a trained facilitator; where the facilitator was a student, a member of staff was present as a note taker.

A facilitator guide defining how the workshops would be run was written by S. Freeman, and distributed in addition to the evidence pack for those who were facilitating each group, and further training was available if required in advance of each workshop. The role of the facilitator was to advise the group on the aims and objectives of the discussion, how to work together, how an appropriate evidence statement is constructed and what constitutes different levels of evidence. The facilitator could also highlight research resources available and a laptop was provided to locate online resources if required by the group. The facilitator was not permitted to influence discussion other than to keep the talks within the appropriate topic area, and to encourage everyone to be included and listened to. The note taker recorded some general comments made by the group during discussion and wrote down finalised evidence statements.

Each group talked through the objectives of each workshop and generated statements based on each objective. Statements followed discussion of the following topics for Workshop One: common clinical signs of colic, clinical signs are associated with critical cases and important information for a veterinary practitioner to collect on initial

examination of colic. Each group discussed the topics in a different order to adjacent groups to avoid the discussion being influenced by other groups. Topics discussed during Workshop Two were: the physical examination approach to the first assessment of a horse with colic, the diagnostic approach and where further education/training/research is required to support decision-making.

Each group had a copy of the evidence pack, statement forms (see Appendix P) and pens along with refreshments throughout the day. One or two members of the research team moved between the participant groups and provided advice when required, encouraged groups to make the best use of time to cover all objectives, and collected completed statement forms. The research team were also available should there be a communication breakdown, or a disturbance of group dynamics. Upon completion, each page of statements was pinned to a board so at the end of the workshop, groups could see the statements generated by other groups. The statements generated from each group were consolidated and placed, unedited, into a combined table for each workshop objective. Statements describing the diagnostic approach to colic generated during Workshop Two (second objective) were categorised by diagnostic test and presented in separate tables.

In preparation for future work and a Delphi process to generate consensus for best practice guidelines, statements with common or duplicated themes/ideas, were combined into a single statement (with the numbers of the original statements so each statement could be

tracked back to the original workshop statement and group). Statements were reworded where necessary, to ensure that they were clear and unambiguous, and appropriately worded for a yes/no voting process (e.g. Abdominal paracentesis Statement 18 '*There is a lot of disagreement regarding the importance of a peritoneal tap at primary assessment of a colic case*.' was reworded as two statements:

1. *Abdominal paracentesis should only be performed in a hospital environment (1, 4, 11, 18)*
2. *Abdominal paracentesis should be performed on a primary assessment (1, 4, 11, 18)*

Any statements that covered several aspects were separated into single statements, so that each component could be voted on in an online Delphi process (e.g. Rectal examination Statement 13 '*An absence of gut sounds, high HR, evidence of violent colic episodes or lack of adequate response to pain relief should warrant a rectal exam if feasible regarding patient cooperation*.' was separated out into three final statements:

1. *Rectal examination should be performed in all cases with an absence of gut sounds on clinical examination, except where safety of horse or personnel is compromised* (13)
2. *Rectal examination should be performed in all cases with high heart rate on clinical examination, except where safety of horse or personnel is compromised* (13)

3. *Rectal examination should be performed in all cases with evidence of severe pain on clinical examination, except where safety of horse or personnel is compromised* (13)

All the statements were circulated within the research group, and to two external collaborators for review and feedback to generate the final statements for later Delphi review.

At the end of each workshop, participants were given a feedback form and the results of these were combined to generate an idea of things that could be improved for future workshops and general opinions about the planning and execution of the event. The research team also observed participant behaviour and noted any both positive and negative interactions during group discussions. They also noted any comments made verbally by participants about their experience of the workshops.

6.3 Results

6.3.1 Multi-disciplinary Workshop One – Recognising colic

This workshop consisted of 26 horse owner/carers of whom 10 were professional and 18 amateur types (Table 28). All owner/carers stated that they had experience of more than five cases of colic; 14 had seen five to ten cases and 14 had seen more than 11 cases of colic. There were 14 veterinary practitioners (seven of which were also stakeholders), and ten stakeholders with representation for three equine

charities (World Horse Welfare, Redwings Horse Sanctuary and The Donkey Sanctuary), one equestrian charity (British Horse Society), one equestrian youth organisation (The Pony Club), three veterinary organisations (British Equine Veterinary Association, Defence Animal Centre and Veterinary Defence Society) and one equine insurance company (South Essex Insurance Brokers, SEIB). Due to unforeseen circumstances there was non-attendance from three veterinary practitioners and four owners on the day of the event.

Photographs taken from workshop one can be found in Figures 30 to 32.

Table 28. Group allocations for multi-disciplinary colic Workshop One

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Veterinary practitioner	1st and 2nd opinion vet	Referral vet and surgeon		1st and 2nd opinion vet	Referral vet and surgeon	1st and 2nd opinion vet	1st and 2nd opinion vet	Referral vet and surgeon
Stakeholder		The Pony Club	Veterinary Defence Society and vet			British Equine Veterinary Association and vet	World Horse Welfare	British Horse Society
Vet and Stakeholder	Donkey Sanctuary		World Horse Welfare	Redwings Horse Sanctuary	Defence Animal Centre	SEIB Insurance		
Owner	Non-Competing Professional 40-50 years	Non-Competing Professional 40-50 years	Competing Professional 30-40 years	Non-Competing Professional 30-40 years	Non-Competing Professional 40-50 years	Competing Amateur 40-50 years	Competing Professional 30-40 years	Non-Competing Professional 50-60 years
Owner	All-Round Amateur 50-60 years	Competing Amateur 18-30 years	Friend/ Companion 40-50 years	Competing Amateur 40-50 years	Friend/ Companion 30-40 years	Non-Competing Professional 18-30 years	Competing Amateur 40-50 years	Competing Amateur 50-60 years
Owner	Friend/ Companion 18-30 years	Friend/ Companion 18-30 years	Non-Competing Professional 50-60 years	Friend/ Companion 50-60 years	Competing Professional 18-30 years	Friend/ Companion 50-60 years	All-Round Amateur 50-60 years	All-Round Amateur 60-70 years
Owner	Competing Amateur 40-50 years	Competing Amateur 50-60 years			Competing Amateur 40-50 years		Friend/ Companion 50-60 years	
Experienced –has seen 11+ cases of colic								
Less experienced – has seen 5-10 cases of colic								

Figure 30. Multi-disciplinary colic Workshop One, held Saturday 22nd November 2014

Figure 31. Group discussions during multi-disciplinary colic Workshop One, held Saturday 22nd November 2014

Figure 32. Participants at multi-disciplinary colic Workshop One, held 22nd November, 2014.

Twenty six statements were generated about a range of clinical and behavioural signs and also the role of the owner in the recognition of colic. There was also a statement regarding the different exhibition of clinical signs for donkeys and other breeds of horse (Table 29).

The second objective (which clinical signs are associated with critical cases) generated 26 statements and detailed a wide range of critical signs. In addition to the onset of violent behavioural reaction to pain which was stated six times, 12 different critical signs were made into statements. Discussion about this objective also focused on the importance of the veterinary practitioner in recognising colic as opposed to the owner (Table 30). The third objective (important information to provide to a veterinary practitioner at the primary examination of a colic case) generated the highest output in terms of time spent in discussion

and number of statements. Consolidated statements included management and behavioural changes, alterations to clinical parameters and owner finances (Table 31).

Workshop One participants were observed by the research team to be enthusiastic and engaged during both plenary sessions and group discussions. Noise level was not reported to be an issue and participants were able to conduct discussions without distraction from adjacent groups. Participants registered concern that the second objective (to generate statements identifying which clinical signs are associated with critical cases) could only be met with discussion from veterinary practitioners and no other members of the discussion groups. The general view was that the decision-making stage for the owner/carer of a horse suspected of suffering from colic should be in recognition of the first signs and subsequently deciding to call the vet. The horse owner should not wait until the case is 'severe enough' to warrant veterinary attention; this is extremely subjective to an unqualified individual and could lead to unethical practice. This led to less time spent in discussion for this objective and limited involvement from some members of the groups. There were no other negative comments on the day and all group members participated fully in other discussions.

There was feedback on the day that owners appreciated guidance directly from veterinary practitioners as to what they could do to help in cases of colic in terms of important information and veterinary

practitioners were more considerate of the role of the owner in speeding up the decision-making process. Responses provided on feedback forms from the participants at Workshop One was extremely positive (Figures 33 and 34); a raw data table of responses from the feedback forms can be found in Appendix Q.

Table 29. Consolidated statements from eight small group discussions at a multidisciplinary workshop with the first objective to generate statements on common clinical signs of colic in the horse.

Group/ Table Number	Statement Number	Final Statement	Number of members agreed (e.g. 4/6)	Source of information (*booklet no., research study, personal experience, personal opinion etc)
6	1	Changes in gut sounds	6/6	Experience
6	2	Walking around box	6/6	Experience
6	3	Behavioural characteristics including lowered head position, unsettled, subdued, depressed	5/6	Experience
6	4	More than one of the following: kicking/pawing, sweating, flank watching, attempts to lie down	6/6	Booklet 5, experience, opinion
6	5	Other signs of pain may include wide base stance, lip curling, yawning, teeth grinding, urination attempts	6/6	Booklet 5, experience, opinion
6	6	Reduced frequency of defecation – other changes in frequency, volume, consistency should not be disregarded	6/6	Experience and opinion
6	7	Not eating feed/reduction in appetite	6/6	None stated
6	8	Not drinking/reduced drinking	6/6	None stated
6	9	A series of subtle physical behaviour changes including changes in facial expression	6/6	None stated
6	10	Deviating from the expected normal patterns of behaviour	6/6	Booklet 3, experience
4	11	Any changes in a horse's appetite such as inappetence, selective appetite, picking at feed/disinterest/reduced intake can be an indication of colic	5/5	Experience
4	12	Any change in faecal output including change in consistency, amount, frequency, colour or odour can be an indication of colic	5/5	Experience
4	13	Any change in physical behaviour such as flank watching, ear twitching, rolling, increased box walking, circling, lying down, abnormal rising, sweating are	5/5	Experience

		associated with colic		
4	14	Any change in demeanour such as lethargy, agitation, change in temperament, isolation, activity level, response to stimuli can be associated with colic	5/5	Experience
1	15	A change from normal behaviour is one of the first signs a horse owner will notice in most cases of colic	6/6	Experience
1	16	Knowing what is normal behaviour for your horse is of vital importance when recognising a case of colic	6/6	Experience, research
1	17	A change in behaviour should prompt you to go onto measure clinical parameters such as heart rate, respiratory rate, faecal output and temperature	6/6	Opinion
1	18	Vets should work with owners to ensure that they are confident and competent at assessing the normal parameters of their horse	6/6	Opinion, research
1	19	A change from behaviour and at least one of the following: demeanour, eating, drinking, defecating, urinating, sweating, flank watching, restlessness, rolling, pawing, kicking, abdominal shape could indicate that a horse is suffering from colic	6/6	Research, experience
1	20	Donkeys and some breeds of horse are likely to exhibit less obvious behavioural signs so many mild changes should be considered significant	6/6	Experience
2	21	Common observed signs in a colic case – flank watching, kicking at stomach, off food, rolling, getting up and down, unsettled, change in behaviour, sweating, yawning, change in faeces appearance and output, pawing	6/6	None stated
7	22	A sudden unexplained change in behaviour would raise suspicion of colic	5/5	Experience, opinion
7	23	If in doubt call the vet	5/5	Experience, opinion
8	24	Identification of abnormal behaviour for that horse would cause suspicion of colic	4/4	Experience, opinion
8	25	Common clinical signs associated would be the horse not eating it's food, getting up and down, rolling, flank watching, thrashing and kicking at belly	4/4	Booklet 3, experience, research, opinion, veterinary training
8	26	There are many other signs that are variable and not exclusively related to colic such as pawing, restlessness, box walking, pacing, reduced faecal output, consistency of droppings, dull/depressed demeanour	4/4	Booklet 3, experience, research, opinion, veterinary training

*Booklet no. refers to booklets distributed to participants as part of the evidence pack.

Table 30. Consolidated statements from eight small group discussions at a multidisciplinary workshop with the second objective to generate statements identifying which clinical signs are associated with critical cases.

Table Number	Statement Number	Final Statement	Number of members agreed (e.g. 4/6)	Source of information (booklet, research study, personal experience, personal opinion etc)
2	1	Severe signs of pain are linked with critical cases: abrasions on the face, violent rolling, excessive kicking at stomach, excessive sweating, heavy breathing with abdominal effort	6/6	Veterinary advice, expertise
2	2	Horses that have become lethargic, unresponsive to stimuli, reluctant to move, cold, clammy ears etc are likely to be critical cases (care that owner doesn't miss these signs)	6/6	None stated
2	3	Painful signs continued after analgesia administered indicative of a critical case	6/6	None stated
2	4	Colic with watery diarrhoea is indicative of a critical case	6/6	None stated
2	5	Any colic case where the horse is straining to pass faeces is a critical case	6/6	Veterinary experience
3	6	Abdominal distension, inappetence/anorexia are signs that a case of colic has reached critical	5/5	Veterinary experience
1	7	Continuing or worsening signs of pain e.g. agitation, rolling, thrashing are likely indicators of a more serious case of colic	6/6	Experience, research study
1	8	In donkeys signs such as flank watching and pawing – although considered milder signs in the horse, are more likely to indicate a critical case due to their inherent stoic nature	6/6	Experience
8	9	It is not possible for an owner to determine if the horse is a critical case	4/4	Experience
8	10	Non-response to pain relief or evidence of extreme pain such as abrasions on the head	4/4	Experience, veterinary training
8	11	Any evidence of cardiovascular compromise such as increased heart rate, abnormal mucous membrane colour and slow capillary refill time	4/4	Experience, veterinary training
8	12	Distended small intestine loops detected on rectal examination (of any degree) or	4/4	Experience, veterinary training

		large intestinal tympany		
8	13	Significant reflux on nasogastric intubation	4/4	Experience, veterinary training
8	14	Significant abnormalities of peritoneal fluid on abdominocentesis such as appearance and clinical parameters	4/4	Experience, veterinary training
7	15	It is difficult for owners to identify critical cases of colic by signs	5/5	Experience, opinion
4	16	An acute onset of violent rolling, increased heart rate, CRT, sweating, distress or abnormal breath odour may be associated with severe colic that warrants immediate veterinary attention	5/5	Experience
4	17	Any changes in a horse's appetite such as inappetence, selective appetite, picking at feed, disinterest, reduced intake and be an indication of colic		None stated
6	18	Lack or absence of a management cause e.g. diet, housing etc	6/6	None stated
6	19	Thrashing around	6/6	Experience
6	20	Gum colour, increased CRT and signs of abdominal pain	6/6	Experience, research
6	21	Signs of pain so severe that self-injury occurs	6/6	Experience, booklet 5
6	22	High heart rate in absence of exercise	6/6	Opinion, booklet 5
6	23	Absence of gut sounds	6/6	Opinion, research, experience
6	24	Absence of critical signs does not mean not critical	6/6	Opinion experience
6	25	Low head carriage	6/6	Opinion experience
6	26	Unremitting signs of kicking, pawing, sweating, flank watching, attempts to lie down	6/6	None stated

*Booklet no. refers to booklets distributed to participants as part of the evidence pack. CRT = Capillary Refill Time

Table 31. Consolidated statements from eight small group discussions at a multidisciplinary workshop with the third objective to generate a list of important information for a veterinary practitioner to collect on initial examination of colic.

Table Number	Statement Number	Final Statements	Number of members agreed (e.g. 4/6)	Source of information booklet no., research study, personal experience, personal opinion etc)
5	1	The length of time since the horse was last seen behaving normally is important in a colic case	6/6	All
5	2	Determining how much pain/distress the owner perceives the horse to be in is relevant to case management	6/6	Experience, research
5	3	Determining the previous colic history of the horse is important in identification and management	6/6	Experience, research
5	4	Gauging the owners previous personal experience of colic is important in identification and management	6/6	Experience, research
5	5	A recent change in management may highlight certain factors that increase the risk of colic in the horse	6/6	All
5	6	Signalment (age, breed, gender) and use of horse may be useful in identifying the type of colic in a horse	6/6	Experience, research
2	7	Important immediate history for vet to take: how long has colic been happening, worsening, severity and frequency of signs, bloated, faecal droppings passed, recent drugs given	6/6	Experience, talking to vets
2	8	For horses no longer showing signs of pain it is important to establish when horse was last normal and if there is evidence of previous colic e.g. abrasions, sweat	6/6	Experience talking to vets
2	9	It is important to identify the exact signs that have been observed by the owner	6/6	Experience talking to vets
2	10	History of previous colic is important – type, surgical, treatment given. Similar behaviour to current episodes, does the owner feel is similar/different to last time. Any trigger factors e.g. management change	6/6	Experience talking to vets
2	11	History of dietary changes e.g. hard feed changes, hay batches, sugar beet	6/6	Experience talking to vets

		properly soaked, turned out to grass		
2	12	History of stabling/housing routine is important – increased stabling, different herd group, exercise changes	6/6	Experience talking to vets
3	13	What perceived abnormal signs is the horse showing that indicated the need for the call out	4/4	Experience
3	14	Have the abnormal signs stated changed and if so how?	5/5	Experience
3	15	When did you last see the horse normal and when did you first see any clinical signs of colic	5/5	Experience
3	16	How has the owner managed and observed the horse since the abnormalities were first seen	5/5	Experience
8	17	It is important to determine how long the colic may have been going on for	4/4	Experience
8	18	It is important to be able to establish what abnormal signs the horse has been showing	4/4	Experience, BHS exams, vet advice
8	19	It is important to determine the owners ranking of the severity of signs of colic for that individual horse	4/4	Experience
8	20	It is important to establish the colic history for that horse and yard management history e.g. recent colic cases	4/4	Experience, knowledge and research
8	21	It is vital to determine the horses clinical parameters such as gut sounds, temperature, heart rate and respiratory rate	4/4	Articles, guide books, veterinary notes for Horse owners
6	22	Changes in management: turnout, box rest, bedding, different hay	6/6	Research booklet 2, experience
6	23	General management questions (without access to water/forage for period of time)	6/6	Research booklet 2, experience
6	24	Parasite control – not in worm control programme, been wormed recently	6/6	Research booklet 2, experience
6	25	Check for clinical signs of colic	6/6	Research booklet 2, experience
6	26	Duration of colic	6/6	Research booklet 2, experience

6	27	Previous history of colic	6/6	Research booklet 2, experience
6	28	Previous medication/action to relieve colic before vet comes	6/6	Experience, opinion
6	29	Where were the teeth last checked	6/6	Experience, opinion
6	30	Financial support available for referral	6/6	Experience, opinion
5	31	It is important to consider and identify any existing conditions and related treatments/management which may be relevant in a colic case	6/6	All
5	32	It is important to determine what actions (medications/lay treatments) may have been given prior to veterinary examination of the horse	6/6	Experience, research

*Booklet no. refers to booklets distributed to participants as part of the evidence pack

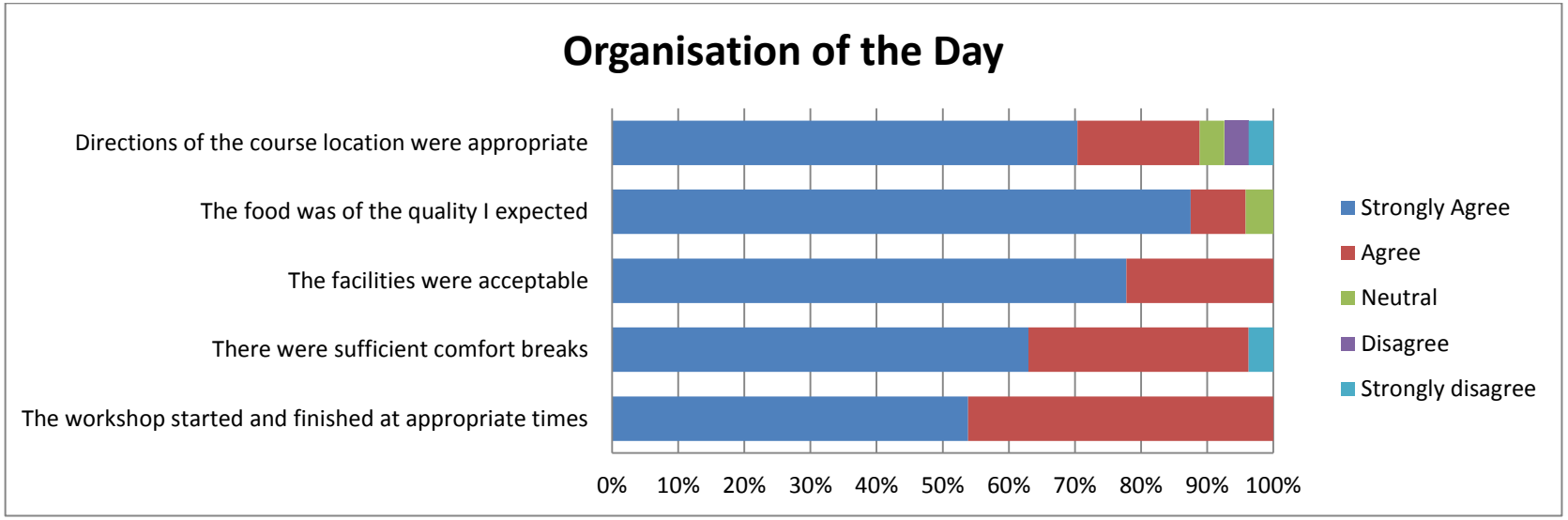


Figure 33. Feedback on the organisation of the day from 27 participants at multi-disciplinary colic Workshop One held on Saturday 22nd November 2014.

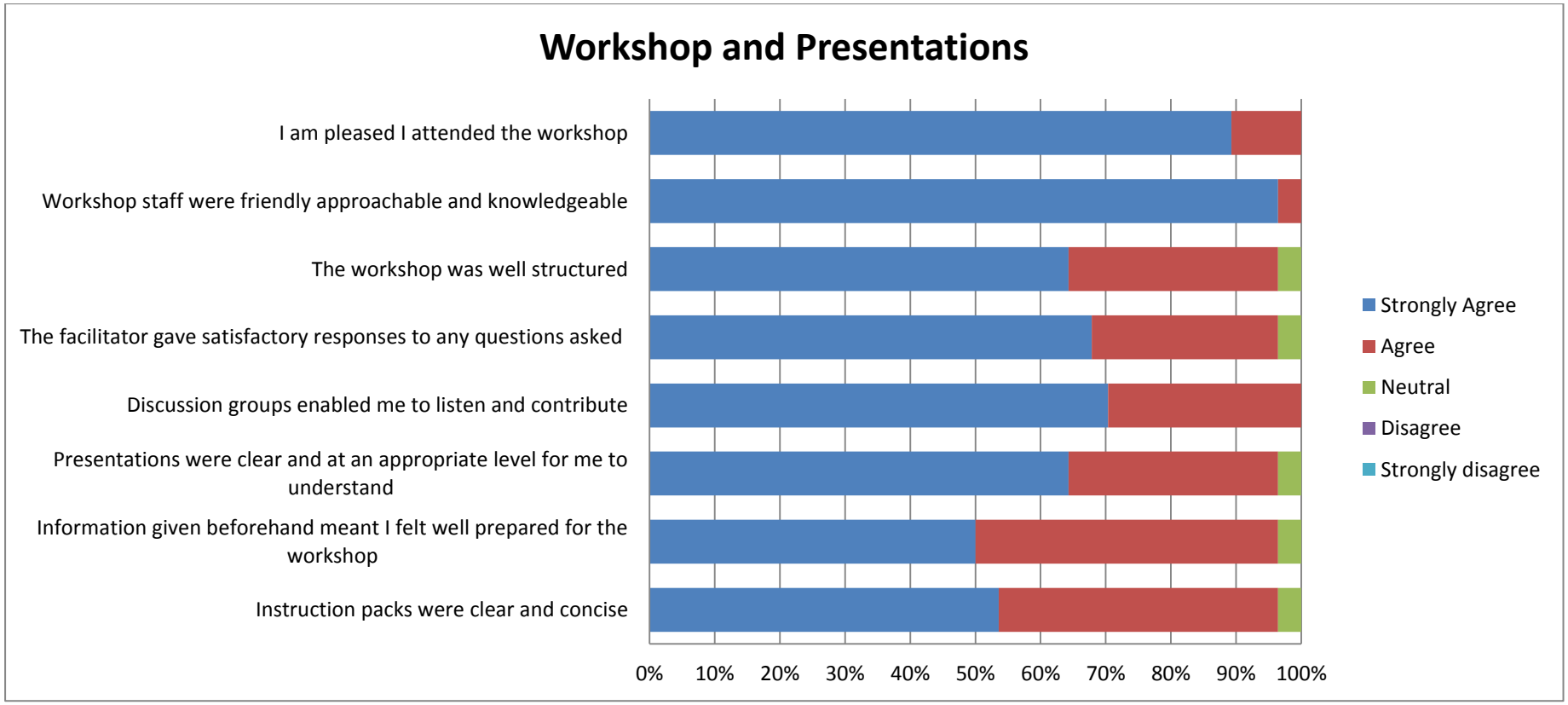


Figure 34. Feedback on the workshop and presentations from 27 participants at multi-disciplinary colic Workshop One held on Saturday 22nd November 2014.

6.3.2 Multi-disciplinary Workshop Two – Diagnosing colic

Workshop Two consisted of 41 participants, of which many were also present at Workshop One. There were 8 horse owner/carers of whom 3 were professional types and 5 amateur types. All owner/ carers stated that they had experience of more than 20 cases of colic and a range of ages (30-70 years) were represented.

There were 21 qualified veterinary practitioners, one veterinary nurse and one fifth year veterinary student. Two veterinary practitioners also represented stakeholder organisations (British Equine Veterinary Association, BEVA and Redwings Horse Sanctuary). There was representation from three equine charities (Redwings Horse Sanctuary, Bransby horse charity and The Donkey Sanctuary), one equestrian charity (British Horse Society), one equestrian youth organisation (The Pony Club), one veterinary organisation (British Equine Veterinary Association) and one equine insurance company (PetPlan Insurance). (Table 32) All workshop participants signed and submitted a consent form. There was non-attendance from two charity stakeholders, two veterinary practitioners and one owner. A photograph taken from workshop two can be found in Figure 35.

Table 32. Group allocation for multi-disciplinary colic Workshop Two.

	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**	**Group 7**
Stakeholder	British Horse Society	PetPlan Insurance	The Pony Club	Redwings Charity – also vet	Bransby Horses Charity		The Donkey Sanctuary
Owner	Friend/ Companion 50-60 years	All-Round Amateur 60-70 years	Non-Competing Professional 40-50 years	Friend/ Companion 40-50 years and All-Round Amateur 30-40 years	Competing Amateur 40-50 years	Non-Competing Professional 40-50 years	Non-Competing Professional 30-40 years
Referral vet	Referral vet	Referral vet and academic	Referral vet and academic		Referral vet and surgeon	Referral vet and academic	Referral Vet and BEVA representative
Graduated < 10 years		New graduate	Recent graduate and postgraduate student	Recent graduate	Mixed practitioner	Small animal practitioner	Recent graduate and postgraduate student
Experienced practitioner	Sole practitioner - surgeon	Experienced vet and surgeon	Experienced vet and surgeon	Experienced vet and surgeon	Experienced vet and surgeon	Experienced vet and surgeon	Vet with over 50 years of experience
Vet/owner	Fifth year vet student and owner	Vet not currently practicing and owner				Veterinary nurse and owner	

Figure 35. Photograph taken during the group discussion of multi-disciplinary colic Workshop Two, held Saturday 28th February 2015.

A total of 59 statements were generated about the physical examination approach to colic. A wide range of approaches were presented and the majority of consolidated statements were focused on assessment of cardiovascular status or behaviour and re-measurement of both after treatment is administered. Other parameters included abdominal and lung auscultation, rectal temperature, skin assessment (abrasions, sweating), examination of faeces (or lack of), abdominal distension, digital pulse (for laminitis) and scrotal examination. Additionally, two group statements referred to owner interpretation of the horse's behaviour. Apart from the following group statement: "*Pulse quality and respiratory rate are still important to be considered but less likely to change your course of action and are subjective*", none of the statements indicated an order of importance for the diagnostic tests. (Table 33).

There was a great deal of enthusiastic discussion for the second objective (diagnostic approach to colic) and some strong views about certain tests. Practitioner confidence and experience were both discussed as influential factors in diagnostic approach: "*If you are not experienced or not confident in performing certain diagnostic tests then don't feel referring is an inconvenience. Most owners prefer vets to act on the side of caution*". Another group statement was: "*Personal experience heavily influences the approach of a practitioner to a case of colic".*

A large number of statements were generated (n=69) about diagnostic tests, these were categorised into rectal examination (Table 34), nasogastric intubation (Table 35), abdominal paracentesis (Table 36) and ultrasound examination (Table 37). Additional comments made in the discussion notes were added directly to these tables of statements where relevant. Abdominal paracentesis, blood tests and ultrasound examination were generally advised as useful additional diagnostic tests, but some group statements suggested that these tests were not considered routinely essential. They were also thought to take too much time and require equipment which was not always available in the field. Contrasting statements about nasogastric intubation included: "*There is a lack of consensus on using NG tube as a routine procedure*" and "*Be aware sensitivity and specificity of NG tube as a diagnostic aid can be dubious*". Owner impression of the procedure was also considered in one statement "*Some owners find NG tube unpleasant or distressing*".

Group statements about rectal examination generally recommended it as an important test: "*Rectal every case where it is safe and practical to do so and the owner consents*" and "*Rectal examination should be performed in all episodes of colic unless the risks to vet or horse are too great*". Apart from contra-indications of personal safety and rectal tears, there were also group statements indicating that a rectal examination is not required in all cases. Statements included: *"Wouldn't rectal something that was only historically abnormal"* and "*A rectal exam is not always indicated if HR and pain score is low and the horse is passing droppings".* There appears to be an expectation from some owners for a veterinary practitioner to carry out a rectal examination in every case: *"If a rectal examination is not done, need to explain why not to the owner and what might still happen".*

Participant groups generated a combined total of 32 statements about further education/training/research to support decision-making (Table 38). Three main themes were identified. Owner education was a prominent theme, and statements were agreed by all the groups that it would be beneficial if owners were able to measure essential physical parameters and therefore give objective information about the status of their horse. An understanding about the different diagnostic test options was also identified as important education for owners. There were consolidated statements about better communication to owners about horse insurance options, specifically the costs of veterinary care including euthanasia and disposal in addition to referral and hospitalisation costs. It was suggested that this educational material

could be delivered by press and charity organisations. One statement was generated about educating veterinary practitioners about effective communication, diagnostic tests and other decision-making topics.

Another theme of the workshop consolidated statements was about veterinary practitioner education, particularly more CPD (Continuing Professional Development) on the rectal examination and colic diagnostic approach in general. Statements also indicated that there was a need for veterinary student education on new diagnostic techniques, equine nutrition and 'red flag' colic protocols. Statements were also generated about better preparation within the veterinary medicine syllabus on nasogastric intubation and rectal examination.

The third main theme of statements about further information required was about more research in areas such as the effects of analgesia on colic cases, and the incidence of rectal tears during the primary assessment of colic and non-colic examinations.

Feedback from participants about the organisation and delivery of Workshop Two were extremely positive, with 100% satisfaction about the workshop in the feedback questionnaire (Figures 36 and 37). Comments about useful aspects of the day included "*Sharing in new, unpublished research and working with other stakeholders from a range of backgrounds*" and "*I enjoyed all - particular discussion group. Appreciate the emphasis on 1st opinion*" (Table 39). Individual negative comments were restricted to factors which were unavoidable ("*Warning of road closure at J24 of the M1, however not the end of the world*") or

relatively minor ("*Too hot in afternoon"*). Plenary sessions by researchers were well received, and all group discussions during Workshop Two were seen to be positive and lively, with contribution from all members. There were no reports of personality clashes and the overall impression from the research team and facilitators was positive and enthusiastic. The research team were informed by two veterinary practitioners and one owner that they intend to organise more discussion groups and training for owners at their own veterinary practice.

Table 33. Consolidated statements from seven small group discussions at a multidisciplinary workshop with the first objective to generate statements describing the physical examination approach to the first assessment of a horse with colic.

Group / Table Number	Statement Number	Final Statement	Number of members agreed (e.g. 4/6)	Source of information (Presentation, research study, personal experience, personal opinion etc)
2	1	Take temperature before rectal examination	6/6	Experience
2	2	Difficulty moving, posture, digital pulses may be indicative of laminitis	6/6	Experience
2	3	Orthopnia/abducted elbows may indicate pleuropneumonia	6/6	Experience
2	4	Temperature >38ºC may be abnormal/suspicious	6/6	Experience
2	5	Clinical exam should include lung or tracheal auscultation, lymph nodes depending on presentation	6/6	Experience
2	6	Changes in pain/behaviour should be interpreted in context of animal and environment e.g. stoic pony, stress, new environment	6/6	Experience
2	7	Assessment of pain – behaviour, elevated respiratory rate, sweating, postural changes, rolling, not eating and flank-watching	6/6	Experience
2	8	Essential physical examination includes TPR, gut sounds, CRT, MM	6/6	Experience
2	9	Degree of distension and “ping” can be useful	6/6	Experience
2	10	Assessment of digital pulses can be useful for diagnosis of laminitis an is helpful for inexperienced vet to identify false colic		
2	11	Essential assessment - signs of pain evaluated by vet, caregiver, owner	6/6	Experience
2	12	Essential questions – when last seen normal/duration of signs of pain	6/6	Experience
1	13	If horse very painful and thrashing HR most important parameter to take on physical exam. It is a good baseline to assess pain and cardiovascular status	6/6	None stated
1	14	Important for vet to assess demeanour and get owners perception of it to help interpret if normal or abnormal for that particular horse	6/6	None stated
1	15	When carrying out a physical exam take into account what has happened before your arrival e.g. any meds given, lunged	6/6	None stated

1	16	Presence or absence of gut sounds is important to assess and help as a prognostic indicator	6/6	None stated
1	17	No clinical parameter alone can give you a definitive answer, need to combine a number of factors found on physical exam and in diagnostic tests to decide what to do	6/6	None stated
1	18	HR and response to analgesia are probably the two most helpful indicators in deciding what to do next in terms of diagnostics and to refer or not	6/6	None stated
1	19	If you have given pain relief and horse has settled with that important to get an update on status of hours in 2 hours or less and tell owner to call sooner if horse worsens. Ring owner if haven't heard from them to check on the horse	6/6	None stated
1	20	On physical exam don't assume colic is the cause, rule out other diseases e.g. take digital pulses, temperature	6/6	None stated
1	21	Superficial abrasions to face and tuber coxae should flag up more severe case	6/6	None stated
1	22	Mucous membrane colour, CRT and jugular fill can all be used to assess cardiovascular status alongside HR	6/6	None stated
3	23	An elevated temperature would change a vet's approach to a colic case and alter list of differential diagnoses	5/5	Experience, training
3	24	Gut sounds must be assessed and any change from normal will dictate part of your course of action alongside history and other signs	5/5	Experience, training
3	25	It is essential to assess the degree of pain. A more severe degree of pain is suggestive or a critical colic case. Signs of severe pain include attempts to lie down, thrashing, rolling	5/5	Experience, training
3	26	Cardiovascular status is always vital including heart rate, capillary refill time, mucous membrane colour but it is important to relate these to normal for that horse and in conjunctive with other clinical signs	5/5	Experience, training
3	27	Pulse quality and respiratory rate are still important to be considered but less likely to change your course of action and are subjective	5/5	Opinion, experience, training
3	28	When establishing a history it is important to establish when the horse was last seen normal	5/5	Experience

3	29	Elements of the history may change your approach to the colic case and alter your list of differential diagnoses	5/5	Experience, opinion
6	30	Every colic case should have heart rate and gut sounds with few exceptions e.g. obviously painful horses	6/6	None stated
6	31	Assessment of mucous membrane may be useful in horses with heart rate	6/6	None stated
6	32	Taking a rectal temperature in the non-violently painful horse can aid in the inclusion of peritonitis, colitis in your diagnosis	6/6	None stated
6	33	Clinically normal and behaviourally normal as judged by the vet and owner	6/6	None stated
7	34	Absence of gut sounds followed by abdominal distension is an indication of a poor prognosis	5/5	Experience
7	35	Horses that are in such pain that they self-traumatise are likely to be critical cases	5/5	Experience, presentation
7	36	In general the greater signs of pain assessed by changes in behavior are more likely to relate to critical cases	5/5	Experience, presentation
7	37	A high heart rate is more likely to be associated with critical cases	5/5	Experience, presentation
7	38	Behavioural signs of pain that don't respond to treatment are more likely to be associated with a critical cases	5/5	Experience, presentation
7	39	A return of high heart rate or pain quickly after treatment is more likely to be associated with a critical case	5/5	Experience, presentation
7	40	Change in mucous membranes that indicate cardiovascular compromise are more likely to be associated with a critical case	5/5	Experience, presentation
7	41	Complete absence of gut sounds is more likely to be associated with a critical case	5/5	Experience, presentation
7	42	Increased respiratory effort combined with other behavioural signs of pain warrants professional assessment	5/5	Experience
7	43	Elevated temperature in conjunction with signs of pain may indicate enteritis/colitis/peritonitis	5/5	Experience
7	44	Absence of faeces for >2hrs warrants rectal exam	5/5	None stated
7	45	Severe diarrhoea warrants examination	5/5	None stated
7	46	Straining warrants examination	5/5	None stated
7	47	Spontaneous nasogastric reflux is an indicator of a critical case	5/5	None stated

7	48	Presence of signs for a prolonged time is more likely to indicate a critical case	5/5	Experience
7	49	In addition to signs of pain if the horse is sweating, trembling or reluctant to more these indicate a more critical case	5/5	None stated
7	50	A focal with colic is more likely to need rapid veterinary treatment	5/5	None stated
7	51	A stallion with colic and a scrotal swelling is likely to be a critical case	5/5	None stated
2	52	Cardiovascular assessment in every case e.g. heart rate, pulse rate, mucous membrane dryness and colour, capillary refill time	6/6	Experience
2	53	Heart rate can be influenced by stress	6/6	Experience
2	54	Colic cases can have a transient murmur without cardiac disease	6/6	Experience
2	55	If heart rate is high listen for longer or re-examine	6/6	Experience
2	56	Heart rate assessment first before given any treatment if possible	6/6	Experience
2	57	GI assessment in every case - listen to gut sounds, loudness, type of sound	6/6	Experience
2	58	Changes in GI signs over time can be useful (repeated exams)	6/6	Experience
2	59	Listen for longer if abnormal, reduced or for caecal signs		Experience

TPR = Total Protein. CRT = Capillary Refill Time. MM = Mucous membrane. HR = Heart Rate. GI = Gastrointestinal

Table 34. Consolidated statements from seven small group discussions at a multidisciplinary workshop with the second objective to generate statements describing the diagnostic approach to the first assessment of a horse with colic – Rectal examination.

Group / Table Number	Statement number	Final Statement (Rectal Examination)	Number of members agreed (e.g. 4/6)	Source of information (presentation, research study, personal experience, personal opinion etc)
3	1	Rectal examination should be performed in all episodes of colic unless the risks to vet or horse are too great	5/5	Experience
3	2	Contraindications to a rectal examination include rectal tears (owners need to give informed consent)	5/5	Experience
3	3	A rectal exam should not be performed in a recumbent horse since it is unlikely to change the outcome	5/5	Experience
4	4	Wouldn't rectal something that was only historically abnormal	3/3	Experience, opinion
4	5	Rectal examination almost always precedes NG tube unless spontaneous reflux or strong suspicion of imminent reflux (yawning, sham drinking, smell)	3/3	Experience, opinion
7	6	A rectal examination is not always indicated if HR and pain score are low and the horse is passing droppings	5/5	None stated
7	7	For donkeys a rectal exam is indicated because they don't show the same pain severity signs	5/5	None stated
7	8	Abnormal findings on a rectal exam are more likely to indicate a critical case		None stated
7	9	First test will be rectal examination but in the donkey and native ponies TGs should be tested also		None stated
5	10	Rectal examination should be the next step after physical examination if possible	5/5	Experience
5	11	If a rectal examination is not done need to explain why not to the owner and what might still happen	5/5	None stated
1	12	Finding a primary impaction on rectal examination warrants NG tube as treatment method to administer fluids	6/6	None stated

1	13	An absence of gut sounds, high HR, evidence of violent colic episodes or lack of adequate response to pain relief should warrant a rectal exam if feasible regarding patient cooperation	6/6	None stated
1	14	Rectal examination early on in diagnostics helps to govern what you want to do next e.g. rules in or out certain disease and especially helps to decide if need to NG tube/peritoneal tap next	6/6	None stated
2	15	Rectal every case where it is safe and practical to do so and the owner consents	6/6	None stated
2	16	Safe environment for rectal exam is essential	6/6	None stated
6	17	Rectal examination should be performed in the majority of cases except where considered to be at excessive risk to the handler, horse or vet		None stated
6	18	A rectal examination should concentrate on differentiation between normal vs abnormal. Appreciate may not be so specific		None stated
*	19	If normal HR probably don't rectal if passing faeces		None stated
*	20	Rectal examination is the next stage after clinical examination if possible		None stated

*Comments made by participants in discussion, recorded by the note taker – not directly on statement forms. HR = Heart Rate. NG = Nasogastric Intubation. TGs = Triglyceride concentration.

Table 35. Consolidated statements from seven small group discussions at a multidisciplinary workshop with the second objective to generate statements describing the diagnostic approach to the first assessment of a horse with colic – Nasogastric intubation.

Group / Table Number	Statement Number	Final Statement (Nasogastric Intubation)	Number of members agreed (e.g. 4/6)	Source of information (presentation, research study, personal experience, personal opinion etc)
3	1	Nasogastric intubation is an important diagnostic test and can help differentiate between a medical and surgical colic	5/5	Experience
4	2	Rectal examination almost always precedes NG tube – unless spontaneous reflux or strong suspicion of imminent reflux (yawning, sham drinking, smell)	3/3	Experience, opinion
7	3	In suspected critical cases a nasogastric tube should be passed	5/5	None stated
7	4	A tube should always be passed in cases of spontaneous reflux	5/5	None stated
7	5	More than 2L of fluid (or any in a donkey) that refluxes through the tube is likely to indicate a critical case	5/5	None stated
5	6	Nasogastric intubation not considered absolutely essential, other tests can lead you to a conclusion to refer		Vets feel is not time well spent, just refer
5	7	Nasogastric intubation tends to be considered if need to treat with oral fluids (based on rectal findings) not as diagnostic	2 vets/5	None stated
1	8	A high heart rate and distended SI on rectal and spontaneous reflux all warrant NG tube	6/6	None stated
1	9	Spontaneous reflux requires immediate nasogastric intubation	6/6	None stated
1	10	Siphon a set amount of fluid in so you know how much there is and can calculate net amount of reflux	6/6	None stated
1	11	Finding a primary impaction on rectal examination warrants NG tube as a treatment method to administer fluids.	6/6	None stated
2	12	Nasogastric intubation should be the first procedure of severely painful cases in case of gastric distension/rupture	6/6	None stated
2	13	NG tube every case	1/6	None stated

2	14	NG tube is indicated if abnormal rectal or abnormal clinical examination in some cases	6/6	None stated
2	15	There is a lack of consensus on using NG tube as a routine procedure	6/6	None stated
2	16	Some owners find NG tube unpleasant or distressing	6/6	None stated
6	17	Don't be afraid to pass a stomach tube if more diagnostic information is required	6/6	None stated
6	18	Be aware sensitivity and specificity of NGT as a diagnostic aid can be dubious	6/6	None stated
*	19	NG tube is of both diagnostic and therapeutic value		None stated

*Comments made by participants in discussion, recorded by the note taker – not directly on statement forms. NG/NGT = Nasogastric Intubation/Tubing. SI = Small Intestine

Table 36. Consolidated statements from seven small group discussions at a multidisciplinary workshop with the second objective to generate statements describing the diagnostic approach to the first assessment of a horse with colic – Abdominal paracentesis.

Group / Table Number	Statement Number	Final Statement (Abdominal paracentesis)	Number of members agreed (e.g. 4/6)	Source of information (presentation, research study, personal experience, personal opinion etc)
3	1	Secondary and additional tests that can be used include abdominocentesis and ultrasound scanning	5/5	Experience
3	2	Blood and peritoneal lactate would be performed more often if the facilities/equipment were available and would be used to help validate decision to refer	5/5	Experience, research study
3	3	In cases where surgery is not an option and owners are looking for validation of their decision for euthanasia, abdominocentesis is useful	5/5	Experience, research
4	4	There is a lot of disagreement regarding the importance of a peritoneal tap at the primary assessment of a colic case	3/3	Opinion
4	5	Good data on lactate, total protein and gross appearance is required to evaluate their use	3/3	Opinion
7	6	In potentially critical cases where a decision has not been clarified about referral/surgery/euthanasia a peritoneal tap for lactate and gross appearance can help decision making	5/5	None stated
7	7	A peritoneal tap is warranted in cases of suspected peritonitis	5/5	None stated
7	8	A peritoneal tap could be a confirmatory test to other rectal findings e.g. mass lesion	5/5	None stated
7	9	A peritoneal tap is contraindicated with severe or widespread intestinal distension	5/5	None stated
5	10	Further tests for deciding prognosis: abdominocentesis and PCV (severe cases). Owner want education about this	3/5	None stated
1	11	Horse Owners don't expect a peritoneal tap to be done on the yard. Many referral practices prefer to do it themselves. May consider doing if need more information and no option to refer	6/6	None stated

2	12	Peritoneal tap essential for unexplained pyrexia, if results will change decision	6/6	None stated
2	13	Peritoneal tap is contraindicated/care with large intestinal disease/impaction	6/6	None stated
2	14	Lactate and PCV/TP is rarely used in the field. Plasma:peritoneal ratio is useful	6/6	None stated
6	15	If obviously distended intestine is palpated rectally abdominocentsis is not worth the risk benefit		None stated
6	16	Abdominocentesis may assist where a surgical lesion is suspected but not confirmed		None stated
6	17	Ultrasound may demonstrate areas where to or not to place your needle for abdominocentesis, s may be preferential to do first		None stated
*	18	There is a lot of disagreement regarding the importance of a peritoneal tap at primary assessment of a colic case		None stated

*Comments made by participants in discussion, recorded by the note taker – not directly on statement forms. PCV = Packed Cell Volume. TP = Total Protein

Table 37. Consolidated statements from seven small group discussions at a multidisciplinary workshop with the second objective to generate statements describing the diagnostic approach to the first assessment of a horse with colic – Ultrasound examination.

Group / Table Number	Statement Number	Final Statement (Ultrasound examination)	Number of members agreed (e.g. 4/6)	Source of information (presentation, research study, personal experience, personal opinion etc)
3	1	Secondary and additional tests that can be used include abdominocentesis and ultrasound scanning	5/5	Experience
4	2	Ultrasound is an underused diagnostic test	3/3	Opinion
4	3	The main factors which prevent the use of ultrasound are experience of the vet with the technique and accessibility of the US machine	3/3	Opinion
7	4	Ultrasound examination may be useful and particularly so in foals for identification of critical cases	4/5	None stated
1	5	In cases where owner/vet wants more information before referring then US can be useful. It can be time consuming especially if clipping so not best for a first line test and equipment is not always available either	6/6	None stated
6	6	If equipment available ultrasound examination can be beneficial for small intestinal lesions showing distended loops especially when not palpated cranially on rectal	6/6	None stated
6	7	Ultrasound may assist where a surgical lesion is suspected but not confirmed		None stated
6	8	Ultrasound may demonstrate areas where to or not to place your needle for abdominocentesis, so may be preferential to do first		None stated
*	9	Ultrasound is useful in small ponies which cannot be rectalled		None stated
*	10	Flash ultrasound is probably underused because of lack of availability and experience		None stated
*	11	More likely to use an ultrasound scan if medical e.g. displacement		None stated
*	12	Ultrasound is less invasive from owners point of view		None stated

*Comments made by participants in discussion, recorded by the note taker – not directly on statement forms

Table 38. Consolidated statements from seven small group discussions at a multidisciplinary workshop with the third objective to identify where further education/training/research is required to support decision-making in the first assessment of colic.

Group / Table Number	Statement Number	Final Statement	Number of members agreed (e.g. 4/6)	Source of information (presentation, research study, personal experience, personal opinion etc)
6	1	More education to students and new grads on abdominocentesis and rectal examination		None stated
6	2	Research is needed to estimate prevalence of rectal tears in the UK		None stated
6	3	Owner education regarding importance of early intervention		None stated
6	4	Vets need to be careful how they discuss insurance with owner	6/6	None stated
6	5	Highly encourage/recommend education of clients with regards to back up plan/contingency plan – arrange transport and if not there what they would want done	6/6	None stated
3	6	More undergraduate training of rectal examination would improve vet confidence and ability to perform rectal exam	5/5	Opinion
3	7	More post-graduate training in the form of CPD opportunities	5/5	Opinion
3	8	More research is needed regarding the risk of rectal tears through rectal examination (may alleviate vet confidence issues)	5/5	Opinion
3	9	Owners should be better educated in understanding what is normal for their horses (e.g. respiration rate, faecal output, temperature)	5/5	Opinion
3	10	Methods of improving client education could include; client education evenings, the vet showing the client at routine vaccinations, fact sheets of normal and colic values, speakers at pony club, online forums/webinars	5/5	Opinion
3	11	More equine internship opportunities, or post-graduate tracking of day one competencies, would potentially lead to better experienced and more able young vets especially rectal examination	5/5	Opinion
3	12	More research into the first assessment of colic cases is needed	5/5	Experience

3	13	More research into the use of blood and peritoneal lactate as a diagnostic test may influence increased use of test	5/5	Experience, research
1	14	Educate owners that nosebleeds as a result of NG tube are not serious and should not deter them from allowing vets to do it	6/6	None stated
1	15	Educate owners that all colic cases are different and they may present differently and respond differently to treatments. This can help manage client expectations	6/6	None stated
1	16	Very important for vet to explain to owner what they are doing and why they are doing it or why they may not be doing something	6/6	None stated
1	17	Vet students get very little training and experience at NG tubing before going into practice. More training in this could increase new graduates confidence in doing this	6/6	None stated
1	18	Educate people on veterinary medicine costs. May help them make better decisions. Early referral can save money on prolonged medical treatment that ultimately results in surgery anyway. Make aware that euthanasia and disposal is expensive as well	6/6	None stated
1	19	Cheaper and more accessible CPD to allow vets to practice and become more confident in certain areas of equine veterinary medicine	6/6	None stated
1	20	New techniques and diagnostic approaches should be taught to students to encourage the best methods of diagnosis and treatment to be brought forward in veterinary practice	6/6	None stated
1	21	Concerns that insurance policies don’t match the rising costs of veterinary care in their premiums Educate clients into taking out the correct insurance for their horses	6/6	None stated
7	22	Client training on doing physical examination and normal values		None stated
7	23	Client training on how to manage a horse with colic		None stated
7	24	Colic fact sheet to include insurance info		None stated
7	25	A talk at BSAVA/BEVA on colic so mixed practitioners get CPD		None stated
7	26	Ensure all vet schools teach “red flag” signs for colic		None stated

7	27	Influence of management and diet change needs more research and communication to clients		None stated
5	28	Vet student education: communication. Reiterate findings, ensure client understands what you will be doing		Communication training
5	29	Owners would appreciate guidelines dissipated through “horsie press” e.g. Horse and hound written by vet		None stated
5	30	Undergraduate education on nutrition so that they can advise owners appropriately	5/5	Owner opinion, don’t trust feed companies
5	31	Educating the horse world: charities could have a role. Vets could give out info sheets on colic when they visit a yard	5/5	None stated
5	32	Research needed about analgesia: no peer reviewed evidence to say flunixin is more potent than any other NSAID, drugs		None stated
5	33	Owner education on normal parameters of horse, signs of colic and process of vets physical examination via information sheets	5/5	None stated
5	34	Owner education; encourage owner to ship horse to hospital if they can due to better observations	5/5	None stated
2	35	Owner education on what to expect in a colic exam and diagnostic tests		None stated
2	36	Owner education – recognizing signs, early identification, education on what can be achieved and long term survival		None stated
2	37	Undergraduates need more rectal training – simulators, practice on cattle, real life experience, access to cases. Practice culture is important e.g. role modelling and support. Difficult in ambulatory practice		None stated

BSAVA = British Small Animal Veterinary Association. BEVA = British Equine Veterinary Association. NG = Nasogastric Intubation. CPD = Continuing Professional Development. NSAID = Non-Steroidal Anti-Inflammatory Drugs

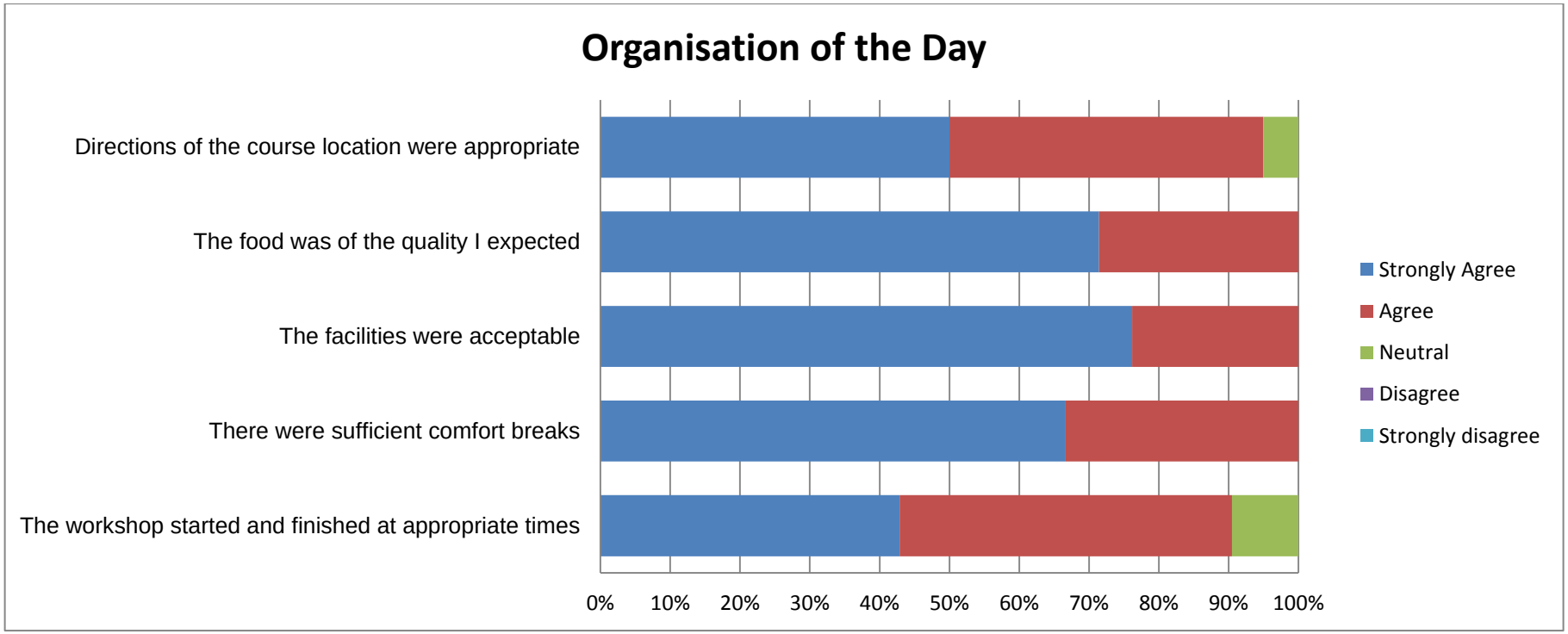


Figure 36. Feedback on the organisation of the day from 21 participants at multi-disciplinary colic Workshop Two held on Saturday 28th February 2015.

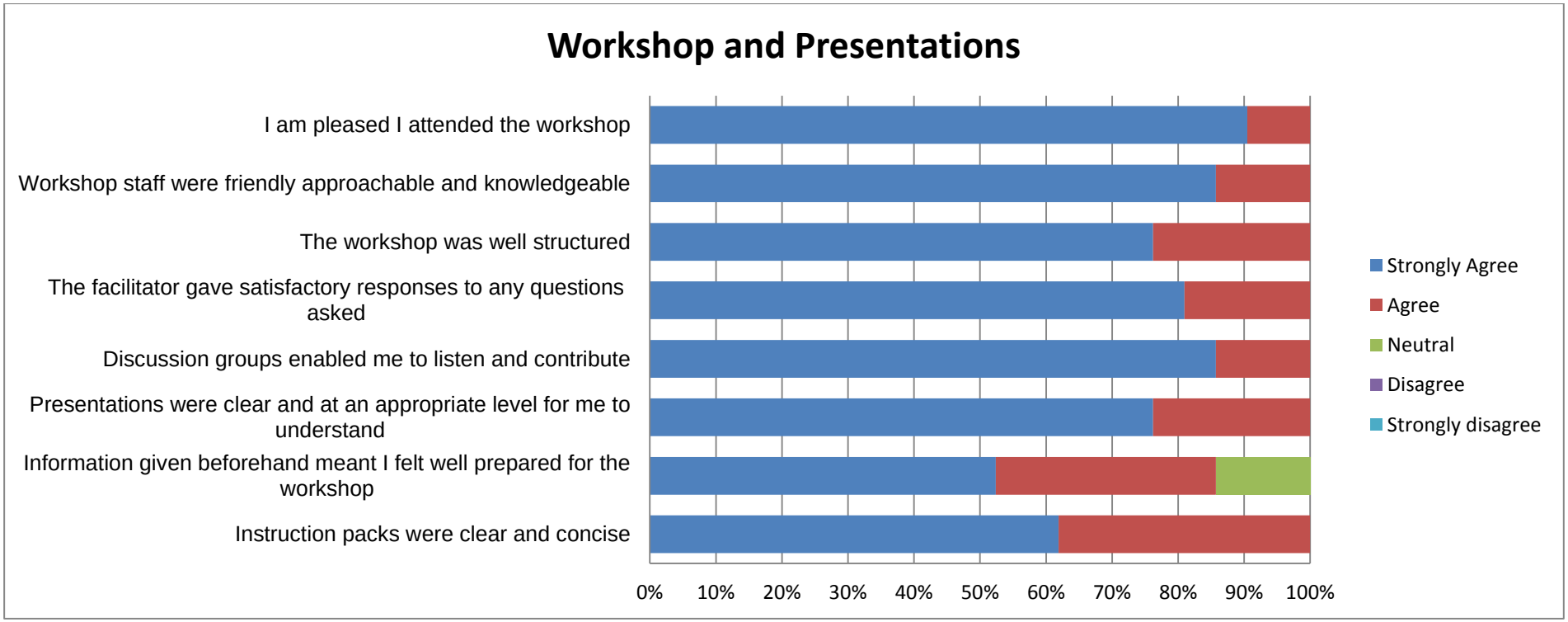


Figure 37. Feedback on the workshop and presentations from 21 participants at multi-disciplinary colic Workshop Two held on Saturday 28th February 2015.

Table 39. General opinions from 21 participants at multi-disciplinary colic Workshop Two held on Saturday 28th February 2015.

What did you find most useful about this session?	**What could have been improved?**
"Sharing in new, unpublished research and working with other stakeholders from a range of backgrounds"	"The speakers in the morning were very quiet and could have used a microphone"
"Range of people to discuss issues with"	"Too hot in the afternoon"
"Meeting people from lots of different areas of the equine world"	"Not very much! Just wish I'd known about the first session in November"
"I enjoyed all - particular discussion group. Appreciate the emphasis on 1st opinion."	"Wish I'd come to the last one! Looking forward to hearing how things progress."
"Learning about other opinions"	"More time for discussion"
"Interesting discussions"	"Start on time (not organisers fault)"
"All discussions were informative and gave me new insights into colic"	"Warning of road closure at J24 of the M1, however not the end of the world."
"Understanding reasons behind colic diagnosis"	
"Discussion with knowledgeable people"	
"Discussion about methods. Chat with owners."	
"Very useful exchange of information between owners and vets, I learnt lots of valuable information"	
"Listening to vets about diagnostic procedures and drugs"	
"Workshop discussion in the afternoon. The two speakers Sally and John were very interesting. Learnt a lot"	
"Comparing different opinions from different stakeholders"	
"Wide range of discussion"	

6.4 Discussion

This study describes the first evidence-based, multi-disciplinary workshop for the generation of statements on the recognition and diagnosis of acute abdominal pain (colic) in the horse. Two workshops were conducted which incorporated veterinary practitioners, owners, veterinary and non-veterinary organisations and other stakeholders, all with a variety of skills and experiences. Evidence was presented in plenary sessions and followed by facilitated small group discussion. During the first workshop, statements were generated on common signs of colic, features associated with critical cases and important information for a veterinary practitioner to collect on initial examination of colic. At the second workshop, statements were generated on the physical and diagnostic examination approach to the first assessment of a horse with colic, and where further education, training or research was required to support decision-making.

The process of consolidation of statements was useful to identify common themes and ideas generated across the different group discussions. There were topic areas which were presented as repeated consolidated statements, showing the importance of these topics to workshop participants. Preparing the statements for distribution as part of a future Delphi panel was a simple process to perform due to the well written statements.

6.4.1 Multi-disciplinary Workshop One consolidated statements

The statements generated in Workshop One highlighted the important role of the owner in the recognition of colic and speed at which veterinary attention is sought as described previously by Scantlebury *et al.* (2014). Several statements mentioned the need for the owner to also be capable of measuring normal and abnormal parameters of their own horse. This topic permitted veterinary professionals in the room to hear the range of owner views and perceptions of when it is the best time to call the vet.

A limitation of the methodology was the inclusion of the second objective (to generate statements identifying which clinical signs are associated with critical cases) in Workshop One which it was recognised in retrospect could not involve discussion by horse owners or other non-veterinary group members. Therefore, apart from contributing experience and opinions, there was little discussion per table about this objective and as a result the statements were not based on group discussion, rather one or two veterinary practitioners per table. Group statements generated were of limited value as part of a multi-disciplinary discussion objective, but did highlight the range of critical signs which veterinary practitioners associated with critical cases. The wide range of clinical signs identified by participants highlights the numerous considerations when deciding if a case of colic is critical (Reeves *et al.*, 1989a) and this presents a challenge to

veterinary practitioners when speed of diagnosis is important (Fischer, 1997; Beccati *et al.*, 2011; Busoni *et al.*, 2011).

The final objective for Workshop One (important information for a veterinary practitioner to receive on initial assessment) generated the most evidence-based consolidated statements and also led to a great deal of discussion. Feedback highlighted that owners appreciated guidance directly from veterinary practitioners. Additionally, veterinary practitioners were given the opportunity to consider the potential for owner involvement in speeding up the decision-making process by giving clear, objective case information to the attending practitioner.

The consolidated statements from Workshop One have demonstrated the importance of the relationship between veterinary practitioners, owners and other stakeholders. The statements have highlighted an opportunity for owners and carers to play a more integrative role in the primary assessment of colic. This type of proactive collaboration between owners and veterinary practitioners has not been proposed previously in the veterinary literature. This presents the potential for evidence-based advice to be implemented as a checklist or form for owners to record important information about a potential case of colic in preparation for the veterinary practitioner to arrive or even when calling the practice. This could be used alongside a list of common clinical signs card similar to the symptom cards used for the recognition of medical conditions such as meningitis (www.meningitisnow.org).

6.4.2 Multi-disciplinary Workshop Two consolidated statements

Group discussions during Workshop Two highlighted some themes in the physical approach to colic by veterinary practitioners, particularly cardiovascular status and behavioural assessment. Indeed these two apparent preferred initial approaches reinforce findings from earlier chapters of this thesis; increased heart rate and behavioural manifestation of pain at first examination were found to be significantly associated with critical cases (Chapter Four). These statements also concur with other published research (Puotunen-Reinert, 1986; Proudman *et al.*, 2005).

The second objective of Workshop Two (diagnostic approach to colic) generated statements which emphasised the complex nature of both first-opinion colic and the decision-making process (Archer, 2004; Archer and Proudman, 2006; Everitt *et al.*, 2013). The consolidated statements were found to incorporate a variety of factors. There were some group statements in Workshop Two which suggested that veterinary practitioner confidence and experience are influential on the selection of some diagnostic tests. This concurs with findings in Chapter Four and Five, and is an area of research which needs more evidence focused on the diagnostic approach to colic. Current evidence is focused on diagnostic decision-making in small animal practice (Everitt, 2011). One group statement also captured that even when a case is resolved, further action is often taken. This could be due to the owner or veterinary practitioner wishing to make sure of the diagnosis

to avoid missing an important clinical sign. It could also be evidence of mistrust between the owner and veterinary practitioner (Foote, 2006), although communication between owner and veterinary practitioner is thought to be complicated (Coe *et al.*, 2008; Stoewen, 2012).

Consolidated statements about abdominal paracentesis were varied and particularly highlighted the lack of consensus of opinion on this test in agreement with research findings (Puotunen-Reinert, 1986; Siex and Wilson, 1992; Singer and Smith, 2002). The statements generated also agree with findings from general practice that abdominal paracentesis, blood tests and ultrasound were used less frequently than other tests (Chapters Four and Five). Some group statements indicated that nasogastric intubation is an important diagnostic test, particularly in suspected critical cases and those where more information is required in agreement with Goncalves *et al.* (2006). Discussion about abdominal paracentesis and nasogastric intubation generated a wide range of opinions, and at least one area where more research would determine their value as a diagnostic test.

Group statements about the importance of the rectal examination, especially for the differentiation of abnormal from normal agree with published literature (Archer, 2004). Apart from contra-indications of personal safety and rectal tears, there were also group statements indicating that a rectal examination is not required in all cases. There appeared to be an expectation from some owners for a veterinary practitioner to carry out a rectal examination in every case.

Traditionally, the rectal examination has been integral to critical colic diagnosis and the literature generally confirms this (Knottenbelt, 1989; Furr *et al.*, 1995; Freeman, 2002). Chapter Five of this thesis however, identified that there are barriers to the selection of the rectal examination. Educating owners about the advantages and disadvantages of the rectal examination and other diagnostic tests may help the veterinary practitioner to make a decision with the informed consent and understanding of the owner (Ubel and Loewenstein, 1997). The colic workshops established a positive step in engaging a communicative relationship between veterinary practitioners and owners about colic. Group statements also identified veterinary practitioner/owner communication as an area of importance within industry as well as the veterinary medicine syllabus; concurrent with the literature (Kurtz, 2006; Everitt *et al.*, 2013).

Group statements from Workshop Two highlighted the requirement for veterinary practitioner education, particularly more CPD (Continuing Professional Development) on the diagnostic approach to colic. The British Equine Veterinary Association already offer some colic diagnostics CPD to veterinary practitioners (B.E.V.A., 2015), however a range of perceived barriers to engagement in CPD were identified by Dale *et al.* (2013). Addressing these barriers is important to ensure that veterinary practitioners have the opportunity to improve their diagnostic approach to colic and update their knowledge of new approaches.

Workshop Two participants also communicated through statements that there was a need for veterinary medicine students to be better educated on new diagnostic techniques, equine nutrition and 'red flag' colic protocols. This would bring up-to-date methods into practice as these students graduate. Statements were also generated about better preparation within the veterinary medicine syllabus on invasive techniques such as rectal examination, congruent with the literature (Baillie, 2007; Knight, 2007; Valliyate *et al.*, 2012). Alternative methods of teaching such techniques could also be included in veterinary practitioner CPD courses. Measuring the impact of this on practitioner confidence would be valuable research. This would also address findings from Chapter Five of this thesis which suggests there are some veterinary practitioners who are less confident in these techniques and others who feel there is insufficient research to warrant the risk of carrying out the tests in some situations.

6.4.3 General reflections of multi-disciplinary workshop discussions

Workshop discussion participants used personal experience and opinion as a source of information for many of the group statements instead of published research or contents of the evidence pack. This may have been due to the larger proportion of owners relying on their own experiences rather than adopting an evidence-based approach. Horse owners may not incorporate published research into their approach to recognising colic, however they were able to provide useful

practical insight and experience, which has been found to be extremely useful in other research (Mallery *et al.*, 1999; Scantlebury *et al.*, 2014). It was assumed that the second workshop, which focused more on veterinary practitioner decisions and had a higher proportion of practitioners, would have generated more research-based statements which were supported by experience and opinion. This was not the case which was surprising, but eludes to a natural preference for intuition before evidence found commonly in experienced clinicians (Greenhalgh, 2002). It may also have been a reflection of the limited importance practitioners place on evidence in their personal clinical decision-making. Despite this, many of the statements from Workshop One, for example: "*Changes in gut sounds*" were clinical signs that had been presented as research findings in the pre-discussion plenary presentations.

The fact that much of the output of these workshops is based on opinion and experience is representative of evidence-based veterinary medicine in general at present. This needs to be addressed partially by educating and guiding the cultural change towards incorporating evidence into practice. Fundamentally there also needs to be research which answers practical, first-opinion questions that can be incorporated realistically into a primary practice setting.

The discussions were commonly stated as the most useful part of the workshops for participants. Other improvements to methodology were implemented following feedback from participants and general reflection

following Workshop One, in preparation for Workshop Two. Firstly the evidence pack was shortened to one concise booklet rather than several booklets to reduce distribution costs and instead present the research using a more interactive format. The timetable of the event was altered to start earlier, with longer presentations sessions and more time for questions before group discussions. Feedback from Workshop Two showed that participants enjoyed the day and found the information presented and gained from discussion was both interesting and valuable.

6.4.4 Impact of the multi-disciplinary workshops

The implications of both events are not just in the generation of consolidated statements but also in the bringing together of representatives of various areas of the equine industry for the betterment of equine health and welfare. Multi-disciplinary workshops are used in veterinary medicine to forward research and communicate with industry, for example The Veterinary Vaccination Network (Vetvaccnet, 2015), but it is uncommon for animal owners and carers to contribute to discussions and policy making. One of the limitations of the development of a consensus statement on astrocytic brain tumours in children using multi-disciplinary conference was the lack of parental involvement (Walker *et al.*, 2013). The colic workshops represent the first time horse owners and members of the veterinary profession have worked together to produce evidence-based statements.

Group discussion enabled new viewpoints to be considered, and this can lead to more open-minded practice whilst bridging the gap in communication between both veterinary and non-veterinary professionals and owners (Oliver, 1995). Additionally, many participants felt they better understood veterinary practitioner decision-making in the diagnostic approach to colic.

Gathering together people representing different areas of the equine world has had an impact on future attempts to improve collaboration between veterinary practitioners and owners. Following the colic workshops, some participants were planning to generate further discussion/training sessions about colic at their own veterinary practice between owners and practitioners. Owner education directly from veterinary practitioners is a positive, proactive way to improve owner/practitioner communication whilst identifying aspects of colic recognition and diagnosis that can be advanced through collaboration (Wiseman *et al.*, 2001; Scantlebury *et al.*, 2014). It is the view of the author that responsibility for owner education should be placed more heavily on the veterinary profession which already has a level of trust with owners (Yeates and Main, 2010; Grand *et al.*, 2013). Charities and voluntary organisations were suggested to provide education to owners in one group statement from Workshop Two. Whilst these organisations have a national presence, which is excellent for dissemination of information, the source of owner guidance should be a multi-disciplinary contribution. Evidence-based multi-disciplinary workshops can begin to

build a set of guidelines which are used by all stakeholders, therefore avoiding the confusion as to ‘which advice is best?’.

Observations from the research team at the workshops described the environment as extremely positive and enthusiastic, with animated discussion from all members; especially in the second workshop where many participants returned after the first workshop. Many strategies were put in place by the researchers to make participants feel confident about the value of their contribution. An example; the evidence packs contained detailed descriptions of what was involved and required, and simplified abstracts were included for each of the pieces of evidence. Presentations contained as few complicated veterinary terms as possible and there was no use of titles on the name badges. LC was regularly in contact before the event so participants could identify with someone on arrival and felt comfortable asking questions. The strategies put in place to make non-veterinary participants feel more included was unfortunately stated as a disadvantage by one veterinary practitioner who felt that the presentations in Workshop One were too simple for practitioners (data not shown). This was unavoidable, and the single negative feedback was outweighed by the large number of appreciative comments on the day and positive feedback forms.

Multi-disciplinary workshops including owners, veterinary and non-veterinary professionals have not been previously documented, and the development of a methodology for the successful execution of further workshops is an important outcome of this study.

6.4.5 Recommendations for future work

1) Further work, out of scope of this thesis, will now be performed using the consolidated statements from both workshops which will be distributed to an expert panel of equine stakeholders including veterinary professionals to strive for consensus as part of a Delphi process. Consensus statements would then be disseminated in the form of evidence-based guidelines for those involved in the primary assessment of abdominal pain in the horse.

6.5 Conclusion

This study documents for the first time, two multi-disciplinary workshops undertaken to facilitate evidence-based discussion between veterinary practitioners, horse owners and other equine stakeholders about colic in the horse. Following small group discussion, statements were generated about the recognition and diagnostic approach to colic and potential areas of improvement. This has highlighted views and opinions about the diagnostic approach to colic which support previous work by the author and justify further work in this area. This study has built on guidance from medical literature and developed a methodology for the successful generation of evidence-based consensus statements. An important implication of this study has been the progress in communication between horse owners, carers, veterinary and non-veterinary professionals with the common objective of improving the

recognition and diagnosis of colic. This in turn has a positive impact on the health and welfare of the horse.

This study was primarily carried out by L. Curtis, who designed the online survey, recruited and communicated with participants, designed, printed and distributed the evidence packs. L. Curtis also hosted both workshops and facilitated one of the groups in workshop one. L. Curtis gathered and processed findings from the workshops. Overall planning of the workshops was carried out by L. Curtis, J. Burford, G. England and S. Freeman and A. Bowden. All members contributed to recruitment of participants and speakers, production of the evidence pack and running of the workshops. S.F. wrote and distributed the facilitator guide. M. Curran assisted with the consolidation of statements into a table from workshop two. Details of student and staff assistance with facilitation and note taking can be found in Appendix R Funding for the workshops was obtained from World Horse Welfare (WHW), and representatives from the charity took part in workshop one. WHW assisted in advertising the workshops and allowed their logo to be used on workshop marketing and evidence packs. Although a copy of all literature was sent to WHW, no contribution was made by WHW in the design and execution of the workshops. Advice was taken from Professor D. Walker at the Children's Brain Tumour Research Centre on the execution of the workshops.

CHAPTER SEVEN: Final discussion

The aim of this work was to combine and also build evidence on the assessment of abdominal pain in the general horse population to develop evidence-based recommendations to support decision-making for veterinary practitioners in the primary assessment of equine abdominal pain.

It is well known that abdominal pain is a major contributor to equine mortality and morbidity; it is expensive and can be extremely distressing for owners and carers of the horse (Tinker *et al.*, 1997a; Proudman *et al.*, 2002b; Egenvall *et al.*, 2008). The veterinary practitioner is responsible for minimising negative effects of the disease as much as possible whilst considering the ethical impact on the horse, as well as the wishes of the owner (Yeates, 2009). This is partly achieved by differentiating critical cases as soon as possible for potential surgery or euthanasia. The speed of this decision can have an impact on the outcome of the case and on the welfare of the horse (Ramey, 2008). Colic is a sign of a variety of diseases and therefore poses a significant diagnostic challenge to veterinary practitioners, who have a different set of experiences, barriers and motivators contributing to their decision-making (Thoefner *et al.*, 2001; Proudman *et al.*, 2006; Coe *et al.*, 2008; Vandeweerd *et al.*, 2012b). The importance and influence of these factors has not been previously documented in reference to investigation of cases of abdominal pain in the horse. This thesis has presented five original studies which have increased the current level of knowledge and developed the evidence on abdominal pain in the horse.

7.1 Overall study design and limitations

The design and purpose of this thesis was part of a long-term objective to develop evidence-based guidelines for the primary assessment of abdominal pain in the horse (Freeman and Curtis, 2015). Development

of guidelines and protocols for implementation in clinical practice requires several important components to ensure quality. The structure for guideline quality as stated within the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument is made up of six 'Domains', and the overall design of this thesis can be linked with the first three (Brouwers *et al.*, 2010). Guidelines/protocols currently used in veterinary medicine have a range of limitations which may affect their quality and validity. The development of the Reassessment Campaign on Veterinary Resuscitation (RECOVER) guidelines did not involve owners in statement development (Boller and Fletcher, 2012). This does not address an influential factor affecting veterinary practitioner decision-making (Everitt, 2011), as discovered in this thesis. The RECOVER guidelines were also based on a systematic review without a validated quality assessment criteria and no prospective survey of clinical practice (Boller and Fletcher, 2012). Systematic review alone may be sufficient where there is a wealth of publications about current practice and published evidence on primary assessment. This was not the case for equine abdominal pain, and systematic review was an essential requirement for this thesis. The Codes of Practice issued by the Horserace Betting Levy Board involved stakeholders including the British Horse Society, but were not based on evidence or consensus and were a product of expert opinion only (H.B.L.B., 2015b). Consolidated statements developed as a result of the work in this thesis were the first in veterinary medicine to involve owners in statement generation and to incorporate a prospective study of colic cases, a

qualitative survey of practitioners and two systematic reviews especially designed with guideline development in mind.

In order to make evidence-based decisions on cases of abdominal pain, veterinary practitioners must combine their own experiences and knowledge, understanding of the evidence base along with the views and wishes of the owner (Vandeweerd *et al.*, 2012a). Development of the evidence base on primary cases of abdominal pain is important because there is a substantial skew towards research in referral populations (Proudman, 1991; Hillyer *et al.*, 2001). Understanding of what happens to cases of abdominal pain in the field is limited; including case presentation, owner and veterinary practitioner decision-making and case outcome. To address this, in accordance with Domain 1: Scope and Purpose within the AGREE II Instrument (Brouwers *et al.*, 2010), a large case series has generated valuable data on cases of first opinion abdominal pain in over 1000 horses and ponies and a survey of veterinary practitioners were undertaken. Also, a small scale questionnaire has investigated the selection of diagnostic tests by veterinary practitioners in the primary assessment abdominal pain and the perceived influences and barriers that contribute to the diagnostic approach. These studies have outlined an overall objective for the guidelines which would aim to support decision-making at the primary assessment of colic and in turn improve the health and welfare of the horse.

In order to identify the target population who would benefit from prospective clinical guidelines, this thesis investigated factors affecting veterinary decision-making in the primary assessment of abdominal pain. The role of the owner was recognised as an important factor, and is an area which needs more attention. Some research has investigated the owner decision-making process when recognising colic and calling for veterinary assistance (Scantlebury *et al.*, 2014). It can be deduced through research and anecdotal evidence that communication between the owner and veterinary practitioner is integral to the recognition, diagnosis and treatment of each case of colic (Kurtz, 2006; Mair and Edwards, 2007; Coe *et al.*, 2008). The 'owner factor' is rarely acknowledged in the literature as part of the veterinary practitioner diagnostic approach, and this is perhaps due to the research bias towards referral populations (Proudman, 1991; Scantlebury *et al.*, 2014). Investigations within this thesis aimed to understand the influence of the owner on the veterinary practitioner decision-making process wherever possible.

Within the AGREE II instrument, Domain 2 requires evidence of stakeholder development, which was addressed in this thesis in several ways (Brouwers *et al.*, 2010). Chapters Four and Five in this thesis describe studies which involved veterinary practitioners, and Chapter Six also involves horse owners, equine charities, equine and equestrian organisations and other stakeholders. These studies have considered the views and opinions of individuals integral to the recognition and diagnosis of abdominal pain in the horse. With reference to the

development of quality guidelines, these studies “include individuals from all the relevant professional groups” (Brouwers *et al.*, 2010).

Within this thesis, two systematic reviews of the literature have been undertaken to address research questions on aetiology and diagnosis of abdominal pain. These findings contribute to the ‘Rigour of Development’ as part of Domain 3 within the AGREE II instrument (Brouwers *et al.*, 2010). The development of guidelines would involve incorporating these findings into the development of recommendations (Stallings *et al.*, 2008). These were the first systematic reviews of abdominal pain in the horse, and they investigate a proportion of the overall literature. There are still more areas of evidence which need to be reviewed including risk factors and diagnostic tests for specific types of colic. The systematic reviews in this thesis contribute to the evidence base by filling significant gaps in the literature, highlighting the bias towards referral cases and they have identified where research is needed. They have also provided a methodological template for further systematic review of risk factors and diagnostic tests within veterinary medicine.

The process of developing recommendations for clinical guidelines commenced when the findings of all four studies within this thesis (Chapters Two to Five) were presented to two multi-disciplinary workshops attended by a variety of stakeholders. The outcome of these discussions was a list of consolidated evidence-based statements about the recognition and diagnosis of abdominal pain in the horse

(Boller and Fletcher, 2012). These five studies have emphasised the importance of the primary assessment of colic in identifying critical cases. The ability to identify critical cases earlier using a few important clinical signs and diagnostic tests has been realised. There is now a greater understanding of the limitations to decision-making of the veterinary practitioner and the influence of the horse owner. This work has contributed to the development of evidence-based clinical guidelines which will have substantial impact on equine health and welfare. Some of the studies have already had a direct impact on the views and actions of individuals involved with horses and it is hoped the impact of this work will continue.

This chapter addresses the construct of the thesis, through each of the studies including justification for some decisions, study limitations, improvements, impact and some suggestions for further work.

7.2 The systematic reviews

Two systematic reviews were performed in this thesis, and both highlighted substantial inconsistencies in methodology of existing publications and a need for better study designs in future research. The low number of UK-based publications in the systematic review of risk factors highlighted the requirement for more data in UK general practice which was targeted in this thesis. Also, the direction of focus to first opinion practice in this thesis can be justified by the bias towards referral populations which was identified in the systematic review of diagnostic tests (Proudman, 1991; Hillyer *et al.*, 2001).

Decisions made during the development of the methodology for both systematic reviews required critique of the literature because there were some options which could not be decided upon in a straightforward manner. One such option was the rating system for the critical appraisal of the included studies. The decision to include grading criteria scoring systems (including scales and weighting schemes) within systematic reviews has led to much debate (Katrak *et al.*, 2004). The decision to choose the QUADAS tool and JBI-MAStARI critical appraisal tools within this thesis require some justification.

As discussed in Chapter One, there are currently two types of system for assessing quality of studies; numeric scoring systems and weighting schemes. Some authors have suggested that scoring articles leads to the introduction of a possible source of heterogeneity in meta-analyses of controlled clinical trials (Juni *et al.*, 1999). According to Whiting *et al.* (2005), using summary scores to differentiate high from low quality is problematic in diagnostic accuracy systematic reviews. In a systematic review of the content of critical appraisal tools by Katrak *et al.* (2004), 49% (n=58) of included tools summarised the results into a numeric summary score, however none of these tools provided justification for this course of action.

Gough (2007) recommended weighting of evidence as a concept which allows the reviewer to ask less specific questions with more extensive inclusion criteria "*in the knowledge that weighted judgements can be applied to the broader range of evidence identified"*. This approach is,

in theory, pragmatic but permits the author of an appraisal tool the freedom to decide which criteria are awarded higher scores without necessarily using evidence-based reasoning. A comparison between a critical appraisal tool using a weighted scheme and a summary score tool without weightings was not found to influence study rankings according to Juni *et al.* (1999).

The weighted scheme approach is adopted in some of the most commonly used critical appraisal tools including those available from CASP (Critical Appraisal Skills Programme) and JBI-SUMARI (Joanna Briggs Institute – System for the Unified Management, Assessment and Review of Information) and the Cochrane Collaboration (Whiting *et al.*, 2006). The lack of a numeric scoring in this system means that the reader must appraise the results themselves and interpret the quality of each study based on presented critical appraisal results. Removing the scoring of criteria reduces the influence of researcher bias on the quality assessment process, providing that the appraisal tool is reliable. This more transparent framework allows the reader to make decisions on both the quality of execution of the study as well as the appropriateness of the design and the relative application of the findings (Gough, 2007). This openness does require more work and time from the reader, and a busy veterinary clinician may just want the 'bottom line' answer. When the methodology of studies is poorly reported, a large amount of "unclear" scores can culminate in vague results with the reader having to interpret the results subjectively (Whiting *et al.*, 2005)..

There are many critical appraisal tools available; both generic and specific to study design or research question. Some are validated and demonstrate a rigorous development process providing an empirical basis for criterion inclusion, however others are not and can lead to invalid and vague results regardless of their choice of scoring system (Sanderson *et al.*, 2007). The majority of scoring systems and grading criteria focus on controlled clinical trials of treatment effects and interventions. Comparatively less attention has been applied to the quality assessment of observational studies in systematic review. Sanderson *et al.* (2007) highlighted the lack of a single generic tool for assessing the quality of observational epidemiological studies, despite including the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist within their systematic review. There is a wide range of critical appraisal tools with no 'gold standard' tool for any study design. Consumers of research are recommended to approach selection of a tool most suited to their study design (Katrak *et al.*, 2004).

It is important for the process of systematic review to be more 'user friendly'; the strengths and weaknesses of the different approaches should be clear to both the researcher and the reader. The decision about which summary scheme to use in a systematic review is arbitrary and debate about each of the options remains inconclusive. The critical appraisal tools chosen for the systematic reviews within this thesis followed a review of the literature and a decision based on the type of studies included in the review and validation of the tool. The

development and recruitment of universally accepted standards or guidelines for critical appraisal would limit the incomparability of studies and in turn – reviews.

7.2.1 Systematic review methodology

In this thesis, the first systematic reviews in the field of equine abdominal pain were undertaken. Evidence was collected, appraised and presented in an accessible format which highlighted the gaps in research (Cook *et al.*, 1997). A successful review was undertaken despite lack of a documented tool for the critical appraisal of risk factor studies in veterinary medicine and limited published systematic reviews of risk factors in the field of veterinary research to use as guidance. For the systematic review of risk factors, two critical appraisal tools were initially developed – the second tool was an amendment of the first following feedback from journal reviewers. The established and validated JBI-MAStARI tool was considered, but it is not designed for the critical appraisal of risk factor studies, or appraisal of cross-sectional study design. We therefore decided to develop a tool specific for studies of risk factors similarly to Wylie *et al.* (2012). Included studies were subjected to scrutiny on susceptibility to bias, study design, but also relevance and applicability of results to first opinion practitioners. Unfortunately, the author was unable to get this method and the systematic review accepted for publication, so reverted to the JBI-MAStARI tool to address reviewer concerns about validation and the use of numeric scoring in the self-designed tool. This was

disappointing and so the self-designed critical appraisal tool and results are presented in Appendices R, S and T but are not otherwise presented or discussed in this thesis. Critical appraisal of included publications using both the JBI-MAStARI and self-designed critical appraisal tools showed that the tools were comparable, with minor differences in the results.

The first systematic review was successful in identifying literature on factors associated with the risk of developing general abdominal pain in horses and ponies through a systematic search of databases. An evaluation of the quality of the publications enabled a summary of the best available evidence (Sackett *et al.*, 1996; Gough, 2007). This was the first systematic review of this literature and so cannot be compared with previous systematic reviews, but has provided a starting point for further reviews and research on potential risk factors. This systematic review showed that there was limited evidence for many factors and their association with abdominal pain. This guided the interpretation of data from general practice in the colic survey (Chapter Four), and provided evidence for discussion at colic workshops during statement generation.

The first systematic review informed much of the methodological practice in the second systematic review. Hand-extraction of studies enabled a more thorough and reliable selection of eligible publication titles than a new literature search using diagnostic search terms. This was most likely due to poor indexing or missing keywords following the

use of search terms within an online search (Minozzi *et al.*, 2000). Authors of publications must more consistently use correct 'tags' and subject identifiers when publishing online (Majdoubi *et al.*, 2009). This is so that those wishing to find specific study types are able to do so without sifting through hundreds (or thousands) of irrelevant studies as was the case with both systematic reviews in this thesis. This has been suggested to have a positive impact on efficient access to documents by Névéol *et al.* (2010). Journals could give more helpful guidance to those wishing to undertake clinical research.

The original diagnostic test systematic review critical appraisal tool was adapted from the final risk factor systematic review tool. Although there are tools available for diagnostic test accuracy (including the QUADAS tool which was used (Whiting *et al.*, 2006)), there were no actual included studies of diagnostic test accuracy, rather the studies evaluated the usefulness or efficacy of diagnostic techniques. As a result, the appraisal tool over-scrutinised the studies and it was often difficult to decide if a study met certain criteria due to the lack of methodological detail (Whiting *et al.*, 2004). To overcome this, publications must be clear about their research objective, and correctly designed diagnostic test accuracy studies are needed.

To meet the 'gold standard' level of evidence, systematic reviews must be used and presented in a clear, practical format to embolden communication between research and clinical practice – particularly first opinion practice (Kitson *et al.*, 1998; Hemsley-Brown and Sharp, 2003).

The application of reviews in practice contributes to decision-making, particularly promoting the employment of ‘red flag’ systems for diseases where a quick decision is integral to optimal outcome (as in the case of equine surgical colic) (Croft, 1999; Sobri *et al.*, 2003; Freeman and Issaoui, 2013). Most cases of equine abdominal pain are seen in the field and assessment commonly takes place in a field or yard setting with poor access to specialised equipment (Cohen, 2003). Veterinary practitioners are often isolated in the field situation, possibly with limited access to colleagues and resources. The development of communication technology and mobile electronic devices has made information much more accessible. This provides an ideal opportunity to develop access to EBVM resources and disseminate recommendations directly to veterinary practitioners in first opinion practice through the use of open access systematic reviews and guidance potentially delivered via apps within mobile devices.

The second systematic review was successful in identifying literature on tests used in the diagnosis of abdominal pain in horses and ponies through a systematic search of databases. An assessment of the quality of the evidence on tests used to differentiate surgical cases from non-surgical cases showed that the literature was of mediocre quality. This was the first systematic review of this literature and therefore cannot be compared with previous systematic reviews, but has provided a benchmark for further reviews and studies to improve the evidence base. The impact of this systematic review on the later work in this thesis was that tests commonly used in general practice (as

identified in Chapter Four), could be used as a guide for implementing focused research on the effectiveness of diagnostic tests. Trends found in the colic survey can also be cross-referenced with views of veterinary practitioners (Chapter Five) to identify areas where practitioners could benefit from further training to encourage the use of some diagnostic tests. It could also support further research in to tests that practitioners avoid using due to lack of confidence in the efficacy of the technique. The findings from this systematic review have also contributed to discussion in the multi-disciplinary workshops (Chapter Six) and to the generation of statements on the diagnosis of abdominal pain in the horse.

7.2.2 Systematic review findings and advice to veterinary practitioners and future research

The first systematic review found that there was a good level of evidence for increasing age, recent change in diet and previous history of abdominal pain to be risk factors for abdominal pain. These results can be integrated to improve the history-taking aspect of the clinical assessment of abdominal pain in the horse (Ramsey *et al.*, 1998). The evidence for other potential associations must be evaluated at the discretion of the practitioner as with any evidence-based decision-making where evidentiary support is lacking or limited (Feinstein and Horwitz, 1997). Particular associations worth investigation include stereotypical behaviour and owner factors such as owner experience, number of horses and attitudes towards aspects of horse management

such as anthelmintic use and dental care. Good quality cohort studies are required to support research already undertaken to identify potential risk factors (Mann, 2003). This will not only lend validity to existing hypotheses but also set a standard for further studies. More inadequately designed studies with inconsistent methodologies will only lead to further unanswered questions and confusion for those trying to practice evidence-based medicine and answer a simple clinical question – 'what are the risk factors for colic? (Altman, 1994). Organisations such as the Nottingham Colic Project, Centre for Evidence-Based Veterinary Medicine (CEVM), British Equine Veterinary Association (BEVA) and RCVS Knowledge (Royal College of Veterinary Surgeons) can play an important role in education veterinary practitioners about what sort of studies should be done.

The second systematic review was unable to confirm a consistent evidence base for the ability of any diagnostic tests to differentiate surgical from non-surgical cases of abdominal pain. This finding is unfortunate, but may empower veterinary practitioners to make judgements based on their own knowledge and experience (Tonelli, 2006). The use of evidence-based medicine in clinical practice is an amalgamation of personal knowledge and experience, owner wishes and research evidence (Sackett *et al.*, 1996). In the absence of solid research, the other two facets must make a greater contribution until research is able to support decision-making in a greater capacity (Naylor, 1995). The research available, particularly publications about diagnostic tests using blood and peritoneal parameters and

radiography, contained useful guidance especially for specific cases and should not be disregarded as a source of reference. More research is needed to validate diagnostic tests used commonly by veterinary practitioners at the first assessment of colic cases as shown in earlier work within this thesis. This would include research into the rectal examination, response to analgesia, ultrasound examination, nasogastric intubation, blood sampling and abdominal paracentesis.

Having reviewed the literature search for both systematic reviews in this thesis, only 30% of publications (82/273) overall met appropriate quality criteria (56.6% (47/83) about risk factors and 18.4% (35/190) about diagnostic tests). It is clear that researchers must stop carrying out studies which are not correctly designed to test diagnostic accuracy or even 'usefulness'. Better, clearer study designs would permit repeatability of research, therefore cementing validity of diagnostic tests (Lindsay and Ehrenberg, 1993). Again, more education for veterinary practitioners in appropriate study design is proposed to encourage larger studies and collaboration between several veterinary practices along with involvement from an epidemiologist.

The systematic reviews in this thesis found most if not all included studies were conducted in referral populations. There are lamentably few useful studies undertaken within primary care practice and within this nothing focusing on diagnostic tests which differentiate between critical cases (Proudman, 1991; Hillyer *et al.*, 2001). Whilst study of the referral population has some value, information about how many non-

surgical cases have been referred; therefore referral population studies are always skewed. Furthermore, they do not describe what happens to cases before they reach the referral hospital – how many have been euthanased due to other considerations such as horse age or owner finances? There is also no information concerning the results of the diagnostic tests at initial presentation in the field – are they congruent with those found at the referral hospital? Importantly, it is not clear whether diagnostic tests results in the field are interpreted in the same way as in the hospital in terms of deciding if a case is surgical or not. Much of the literature based in referral populations has virtually no value to a first opinion practitioner who cannot make use of the same facilities and equipment in many cases.

The second systematic review and other findings from this thesis suggest that further research on diagnostic test accuracy (rather than usefulness or efficacy) is warranted. In particular, studies in blood and peritoneal fluid parameters which can be assessed in the field appear interesting, but current studies are sporadic in their focus. The selection of ultrasound examination as part of the diagnostic approach generated debate in the colic workshops (Chapter Six). This test was commonly identified in the survey of veterinary practitioners as an 'attractive' option which needs more research in to its sensitivity and specificity (Beccati *et al.*, 2011). More research into ultrasound examination would justify the need for more Continuing Professional Development (CPD) to incorporate the research into clinical practice and encourage the purchase of in-field equipment.

Further research is also needed in the rectal examination, for example an investigation into the incidence of rectal tears to build on existing case series (Watkins *et al.*, 1989; Mair, 2000). It is the view of the author that this important diagnostic test is a major cause of worry in some veterinary practitioners, and the rectal tear is such a 'taboo' topic that those practitioners with less confidence are less likely to seek advice on the subject. More focus on the test through research and CPD would perhaps alleviate some of the fears associated with rectal tears and encourage some veterinary practices to have a more positive stance on their practitioners performing rectal examination.

7.3 The prospective study of case presentation and clinical signs on primary presentation of abdominal pain in the horse

The collection of information directly from first opinion veterinary practitioners about cases of abdominal pain was one of the most important objectives of this thesis. The survey collected details about signalment, diagnostic approach and outcome data from 1016 cases; information that has never been previously documented. In this study, the primary diagnostic approach by veterinary practitioners mostly consisted of history taking, clinical examination and rectal examination findings; other diagnostic tests were infrequently used. Non-steroidal anti-inflammatory drugs (NSAIDs) and spasmolytics were the most commonly used treatments, but treatment of cases was not the primary focus of this study. A multivariable model undertaken to examine which variables were significantly associated with critical cases identified

combined pain score, heart rate, capillary refill time, pulse character and absence of gastrointestinal borborygmi in at least one quadrant. Apart from collecting important information about primary evaluation of cases of abdominal pain, this survey brought the first opinion stage to the forefront of importance. Filling the gap in evidence about what happens to the horse before it reaches the referral stage was essential, primarily because of the implication of the first assessment stage on the potential outcome of surgical cases (Fischer, 1997; Singer and Smith, 2002; Beccati *et al.*, 2011; Busoni *et al.*, 2011).

This work also had an impact on the survey of veterinarians presented in Chapter Five. The decision to investigate the decision-making process of veterinary practitioners in terms of their diagnostic test selection was primarily based on the variation in test selection identified in the colic survey. It was clear that there were reasons other than the presenting clinical signs of the horse that influenced the veterinary practitioner's decision to use/not use a diagnostic test, and this has been alluded to in first opinion small animal practice Everitt (2011). Some information was given in the free text responses within the colic case assessment form, and this was justification for a more indepth investigation.

The enthused involvement of many first opinion practitioners in this survey has not only justified the need for more focused research in first opinion colic practice, but also provided a register of participants for studies in Chapter Five and Chapter Six. There are veterinary

practitioners who have participated in all three studies and wish to be continually informed of results. This is an excellent unforeseen outcome because the ‘Nottingham Colic Project’ is gaining recognition through word-of-mouth which has potential for recruitment of participant for further studies but also promulgation of research findings. Distribution of research findings at practice level is ideal to encourage the practice of evidence-based medicine (McColl *et al.*, 1998).

There were several limitations to the research which will be discussed directly. The survey was essentially a large case series which is considered a low level of evidence (Cockcroft and Holmes, 2003). Without the existence of a similar study to build upon and also the funding to carry out a nationwide prospective cohort study, the current study design was inevitable. Despite this, an investigation into the field of intended research is essential to secure large-scale funding, so this survey may contribute to the justification for such a study.

More in-depth critique of survey questions and the analysis of results during the pilot phase would have highlighted areas of potential improvement (Van Teijlingen and Hundley, 2001). One example was the free text answers for the ‘date last wormed’ question; there was too much variation in the style of responses and this made it difficult to format the results into categories. As a result, a lot of time was taken to individually and subjectively categorise the responses, inevitably (although not intentional) classification bias may have been introduced.

An aspect of personal interpretation was also required on some occasions to more specifically categorise the type of colic suggested by the veterinary practitioner. The author broadly categorised every entry and a veterinary surgeon (SF) allocated a more specific presumptive diagnosis based on the clinical information provided in other areas of the data capture form. This took a great deal of time, and there is a possibility that some diagnoses were incorrectly interpreted and categorised (Croskerry, 2008). In hindsight, an improvement of this methodology would have been to request more detail on what clinical information contributed to the decision to allocate a presumptive diagnosis. A long tick list of possible diagnoses would have reduced the time taken to categorise the results, but could have influenced and limited the responses.

A decision should have been made earlier on what to do with abdominal pain case forms that originated outside the UK, and whether the responses received from foreign cases could be included and extrapolated from when inferring to the population. Finally, it was decided to accept or reject forms from foreign countries based on a personal interpretation of the living environment and management of the case. This was decided following scrutiny of the completed case form and in some cases research into the veterinary practice or yard location. Veterinary practitioners from the Hong Kong Jockey Club for example submitted 20 case assessment forms which were routinely accepted following investigation of the living standards of the horses

and the regular veterinary contact which ensured complete clinical history was known.

A suggestion for a long term outcome for this work would be the development of a practice-based data collection network for the provision of further research resources similar to the Small Animal Veterinary Surveillance Network (SAVSNET) (Radford *et al.*, 2010; Tierney *et al.*, 2011). If equine veterinary practitioners collected the same information from each case of abdominal pain seen on a first opinion basis, there would be a substantial database of information which could be shared. This could contribute to research into aspects of colic management and surveillance of disease trends. Most importantly, practice-based research would promote the enthusiasm towards evidence-based medicine because the research is focused on first opinion cases.

7.4 The survey of veterinary practitioners' opinions of diagnostic tests used in the primary evaluation of equine abdominal pain

The survey of veterinary practitioners successfully gathered evidence from 228 veterinary practitioners on which tests they preferentially used in the initial diagnostic approach to colic, and factors which influenced decision-making in these situations. The complexity of decision-making has been discussed in small animal practice, but has never been previously investigated in equine practitioners (Everitt, 2011). An association was found between individual veterinary practitioner factors (such as confidence and work environment) and their choice of

diagnostic test. The findings from this survey are important for understanding why there is a wide variety of diagnostic approaches by veterinary practitioners to cases of abdominal pain, presented in the colic survey (Chapter Four). The six tests chosen as the main focus of the questionnaire came from data gathered in the colic survey (rectal palpation, abdominal paracentesis, nasogastric intubation, haematology and biochemistry, ultrasonography, and response to analgesia/treatment). These tests were most commonly selected by front-line practitioners or identified as important tests in the diagnostic work-up of cases of abdominal pain (Chapter Four).

The veterinary practitioner survey has gathered specific information about the complexity of the decision-making process in equine abdominal pain, and confirmed that there are several reasons why veterinary practitioners may or may not select certain diagnostic tests. The challenges of the diagnostic approach to colic have been discussed elsewhere (Thoefner *et al.*, 2003; Vandeweerd *et al.*, 2012a), but not investigated in detail. The implications of these findings are that more work can be focused towards supporting the selection of certain diagnostic tests. This may be in the form of more research into diagnostic test accuracy to justify the use of a test, or more CPD or student practical training to increase confidence in practitioner ability, for example in rectal examination or ultrasound (Lofstedt, 2003; Nippert *et al.*, 2011). Any further research in diagnostic tests for the primary assessment of abdominal pain in the horse must be considered in light of the reasons why practitioners may not use them. More studies

focussing on colic cases in the field would inherently need to consider the practicality of using the test at the first opinion stage.

The veterinary practitioner survey has provided useful answers to contribute to the reason for wide variation in practice shown in the colic survey. The findings will be interesting to veterinary practitioners working in first opinion practice and also to practice managers who may wish their staff to avoid or preferentially select certain tests such as the rectal examination. This study is the first to contribute equine veterinary practitioner views and opinions to the evidence base, which were not previously documented, which may impact on the focus of future research on diagnostic tests. The engagement with practitioners has demonstrated effective collaboration between research and clinical practice which has been concurrent throughout the majority of this thesis.

7.5 The multi-disciplinary workshops on recognising and diagnosing abdominal pain in the horse

The multi-disciplinary colic workshops successfully brought together stakeholders from various facets of the equine industry to generate discussion and to develop statements about recognising and diagnosing abdominal pain in the horse, based on evidence. The workshops permitted an amalgamation of all the research conducted within this thesis in the form of an evidence pack that was presented directly to representatives of the equine industry. It is the view of the author that achieving this through any other method (conferences,

practice visits or yard visits for example) would not have led to such a constructive outcome. Group discussions between veterinary practitioners, owners, charity workers, and other stakeholders on aspects of abdominal pain in the horse have not previously been documented, and this in itself is a positive achievement. Communication between veterinary practitioners and owners has been identified as an area which could be improved (Shaw *et al.*, 2004; Frankel, 2006; Coe *et al.*, 2008). Bringing representatives from both groups together in these workshops appeared to encourage participatory decision-making and highlighted the implications of different views and experiences on statement generation.

The workshops gave participants the opportunity to understand the evidence on the primary assessment of abdominal pain and combine these findings with their own views and experiences. Following this, the group discussions enabled participants to appreciate others' views and experiences before building consensus on statements which considered all these variables (Burgess and Spangler, 2003). It was necessary to incorporate both veterinary expertise at a range of levels as well as other stakeholder experiences of abdominal pain to generate statements that were realistic as well as clinically correct (Sherman *et al.*, 2009). The result was a set of evidence-based statements that also appreciated the practical and ethical considerations of both veterinary practitioner and others involved in the primary assessment of abdominal pain in the horse.

Workshops are commonly executed in the medical field to identify research recommendations and work towards consensus on impending issues (de Franchis, 2005; Estep *et al.*, 2008). Publications about workshops tend to focus on the results and outcome of the discussions rather than the planning and execution. There is some interpretation of the sociological and psychological aspects of group workshops in science and politics (Andersen and Jæger, 1999; de Vivanco, 2002). There is no documented review of the planning and execution of a multi-disciplinary workshop such as this to compare to and any perception of the success of the event is therefore based on self-reflection and participant feedback.

There were some aspects of the workshops which caused challenges in planning and execution. These may not have impacted on the results, but are nevertheless factors which would be addressed if the workshops were to be repeated. There were some difficulties in recruiting veterinary practitioners to attend the workshops, despite enthusiasm for the concept. Incentivising participation did go some way to recruiting practitioners, also a published article in the Veterinary Record about the first workshop to show that the first workshop was successful and to convert those with initial doubts (Freeman and Curtis, 2015). Extending the presentation time for the second workshop gave participants more for their time, i.e. professional development in the form of educational presentations of novel research. There was not enough time to arrange some veterinary CPD in addition to the workshops, and this may have encouraged more participation from

veterinary practitioners. One of the implications of the colic workshops are that recording the planning and execution (including limitations) of the workshops has provided a template methodology for future researchers wishing to undertake similar research, or replicate the colic workshops.

This study described not only the first ever multi-disciplinary workshop in abdominal pain in the horse, but the first equine veterinary workshop to include owners in the development of statements. Group discussions emphasised finding from other work in this thesis about commonly used approaches; predominantly cardiovascular status and behavioural manifestation of pain. Rectal examination, abdominal paracentesis, nasogastric intubation, blood tests and ultrasound examination were integral topics of discussion and group statements supported several findings in this thesis and other research.

Consolidated statements from multi-stakeholder discussions highlighted the important of the owner in the recognition of colic, and also how the owner can assist to improve the speed of critical case diagnosis (Scantlebury *et al.*, 2014). This has the potential to make a real difference in practice and is an area which is worth further research. Recommendations for further education and research were identified, focusing on veterinary practitioners, students and owners. This presents an opportunity for innovative and collaborative ventures to implement shared knowledge and understanding developed as a result of the consolidated statements.

CHAPTER EIGHT: Recommendations for future work and conclusions

The studies within this thesis advanced the evidence base in primary practice whilst involving multi-stakeholder perspectives. They engaged veterinary practitioners and challenged the veterinary profession to incorporate more collaboration and consensus within its research and development. There is clear scope and purpose to incorporate this research into future work with implications for clinical practice.

There is a requirement for guidance in the recognition and diagnosis of equine abdominal pain, especially for veterinary practitioners with limited experience and/or confidence. This can be achieved through evidence-based guidelines (Kawamoto *et al.*, 2005) which would support decision-making during the primary assessment of colic and hopefully make the process more efficient and consistent, in the best interests of the horse (Woolf *et al.*, 1999). Best practice guidelines are needed for veterinary practitioners in the diagnostic approach of first opinion abdominal pain cases, particularly for the differentiation of critical cases. Guidelines are also needed for owners in the recognition of colic.

Evidence-based, agreed statements on the recognition and diagnosis of equine abdominal pain have been contributed to by every chapter of this thesis and can be incorporated into further work on guideline development. Wider, thorough statement consensus through a Delphi process of stakeholders would bring unified guidance to veterinary practitioners, owners and other stakeholders a step closer to realisation (Black *et al.*, 1999).

Guidelines would be available for veterinary practitioners to support the diagnostic approach to the primary assessment of abdominal pain in the horse and the differentiation of critical cases. Guidelines would also be available for owners to support the recognition of colic, when to call the veterinary practitioner, and what information to provide when the practitioner arrives (Miller and Kearney, 2004). Dissemination would follow a marketing campaign including presentation of the findings at a national conference (for example BEVA Congress) and submission of an open access publication. A 'roadshow' to include charity organisations, riding schools, livery yards and Pony Club events amongst other visits would advertise and inform the use of the owner guidelines. Furthermore, individuals and organisational contacts such as British Equine Veterinary Association (BEVA), World Horse Welfare and the British Horse Society could distribute symptom cards and advice booklets. Symptom cards would be similar to those produced and disseminated by the Headsmart campaign (Headsmart, 2011).

Following completion of the Delphi panel consensus process, the final statements would be marketed and prepared for dissemination (Grimshaw *et al.*, 2004; Miller and Kearney, 2004; Barosi, 2006). The aim would be to develop an education campaign to assist horse owners and veterinary practitioners in the early recognition and diagnosis of colic. The detail of the content of the educational campaign would be determined by the outcomes of the Delphi process, but the target audiences would be:

1. Horse owners / the public
2. Veterinary practitioners / veterinary practices
3. The research and scientific community.

The development of a mobile smartphone application (app) to allow access to the guidelines would be extremely useful to busy practitioners and horse owners who are now more likely to have access to a modern phone or tablet in the field (Franko and Tirrell, 2012; O'Neill and Brady, 2012). Mobile apps could also be used to develop a form similar to the case assessment form used for the colic survey (Chapter Four). This would provide a systematic record collecting device for practitioners to refer to later when completing paperwork, or revisiting the case. It could also be integrated with the practice management system and form a data collection strategy for research or clinical governance and practice audit purposes. If several practices adopted use of the same app, and colic case data could be collected regularly, a national colic database could be attainable.

This research has shown that primary practice research is possible and practitioner engagement, although challenging can be achieved with efficient project management. There has been a high level of interest in the potential for the development of a large-scale, multipractice database of colic surgery (Mair and White, 2008; Mair, 2009). Using a standardised form like the one used in Chapter Four would permit data collection that could be collected across multiple practices and permit large scale studies of colic in first opinion practice. Not only would this provide data for further research and review of guidelines, but work could go into developing a predictive app based on a multivariable model (model as shown in Chapter Four, section 3.12). Such an app would be able to provide veterinary practitioners with an idea of how likely a case is to be critical based on the variables entered in to the model. The result would be an extra strand of evidence-based information to support decision-making. Use of this system would need careful management to ensure practitioners did not rely on this result but used it as an ingredient to their evidence-based approach.

An important contribution to evidence-based medicine following on from this research would be the development of Best Bets for practitioners to incorporate into their decision-making. These Bets could be generated using the specific cases collected as part of the prospective survey of first-opinion cases in Chapter Four. Another important addition to the evidence base would be to continue the systematic review searches in this thesis and appraise risk factors and diagnostic tests for specific types of colic.

Following reflection of the findings from the surveys and workshops, it is apparently important to get support from vet schools on colic approach and curriculum. National agreement from vet schools on approach to first-opinion colic will influence future generations and amend general approach. This research shows that it is integral to increase priority of primary assessment as opposed to referral skills. The RCVS day one skills need to include more reference to practical assessment of colic cases.

This thesis has built upon a limited evidence-base to describe what veterinary practitioners are doing in the primary assessment of abdominal pain in the horse and why they are/are not making certain decisions. The evidence gathered through systematic review, research in practice and multi-disciplinary discussion has identified gaps in understanding and made suggestions about the way to improve what happens in practice. The next step is to disseminate those suggestions in the form of consensus statements and measure the impact they have on the industry. This will culminate in a continuous cycle of research, interpretation, improvement and assessment of practice for the betterment of the recognition and diagnosis of abdominal pain in the horse.

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LIST OF APPENDICES

Appendix M: Description of owner typologies used to categorise owners into categories for multi-disciplinary workshops

Appendix N: Form used to gain consent from participants at multi-disciplinary workshops

Appendix O: Evidence pack sent to participants of multi-disciplinary Workshop Two

Appendix P: Form used to record consensus statements during multi-disciplinary workshops

Appendix Q: Participant feedback from multidisciplinary Workshop One

Appendix R: Self-designed quality appraisal tool for a systematic review of risk factors for equine abdominal pain

Appendix S: Quality assessment results for 35 publications in a systematic review of risk factors for equine colic

Appendix T: Combined quality assessment results for 35 publications in a systematic review of risk factors for equine colic

Appendix A: Business card design

Front

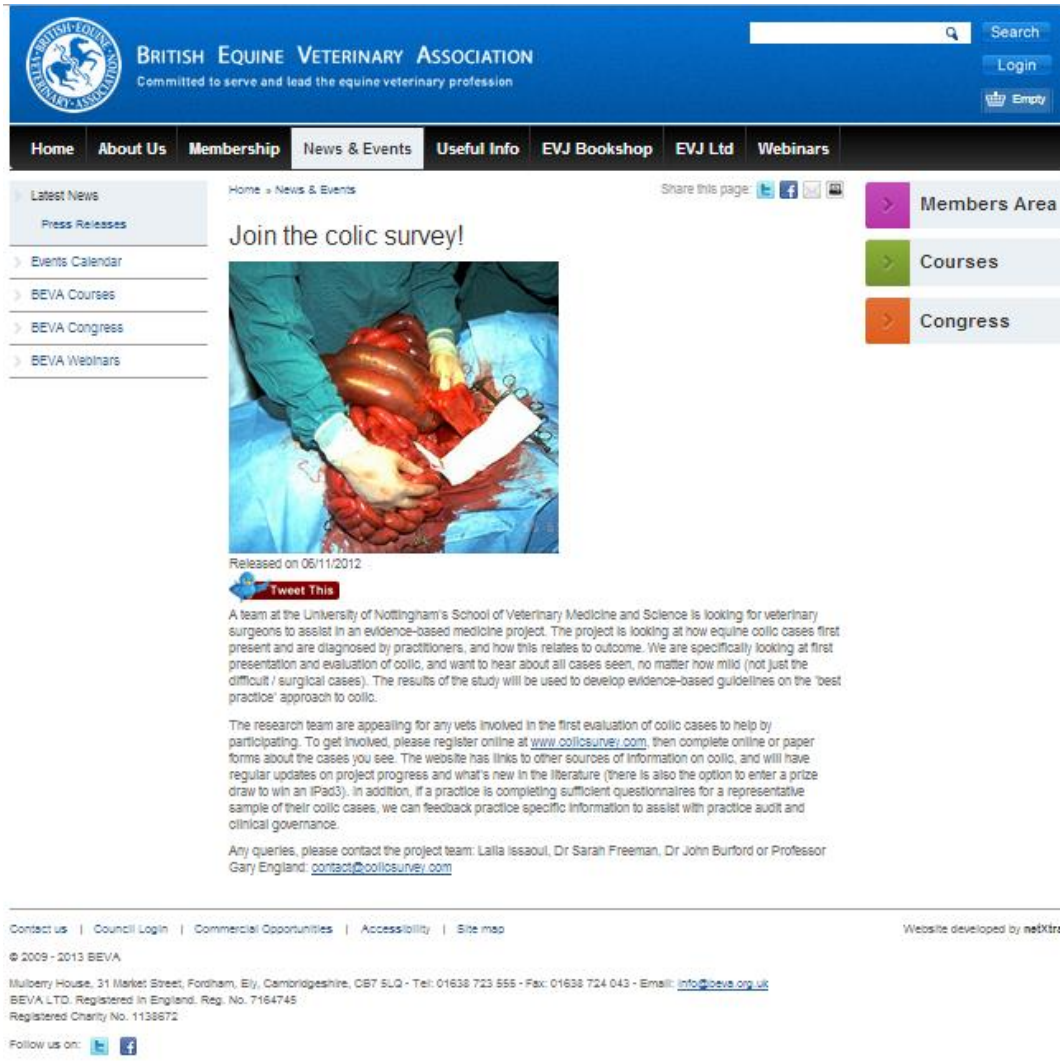
Back

Appendix B: Print screen of a press release for the colic survey taken from University of Nottingham website.

Taken from:

http://www.nottingham.ac.uk/news/pressreleases/2012/december/transforming-diagnosis-of-equine-colic.aspx

Appendix C: Print screen of a press release for the colic survey taken from British Equine Veterinary Association website.



BRITISH EQUINE VETERINARY ASSOCIATION
Committed to serve and lead the equine veterinary profession

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Join the colic survey!

Released on 06/11/2012

Tweet This

A team at the University of Nottingham's School of Veterinary Medicine and Science is looking for veterinary surgeons to assist in an evidence-based medicine project. The project is looking at how equine colic cases first present and are diagnosed by practitioners, and how this relates to outcome. We are specifically looking at first presentation and evaluation of colic, and want to hear about all cases seen, no matter how mild (not just the difficult / surgical cases). The results of the study will be used to develop evidence-based guidelines on the 'best practice' approach to colic.

The research team are appealing for any vets involved in the first evaluation of colic cases to help by participating. To get involved, please register online at www.colicsurvey.com, then complete online or paper forms about the cases you see. The website has links to other sources of information on colic, and will have regular updates on project progress and what's new in the literature (there is also the option to enter a prize draw to win an IPad3). In addition, if a practice is completing sufficient questionnaires for a representative sample of their colic cases, we can feedback practice specific information to assist with practice audit and clinical governance.

Any queries, please contact the project team: Laila Issaoui, Dr Sarah Freeman, Dr John Burford or Professor Gary England: contact@colicsurvey.com

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Website developed by net

Mulberry House, 31 Market Street, Fordham, Ely, Cambridgeshire, CB7 5LQ - Tel: 01638 723 555 - Fax: 01638 724 043 - Email: info@beva.org.uk
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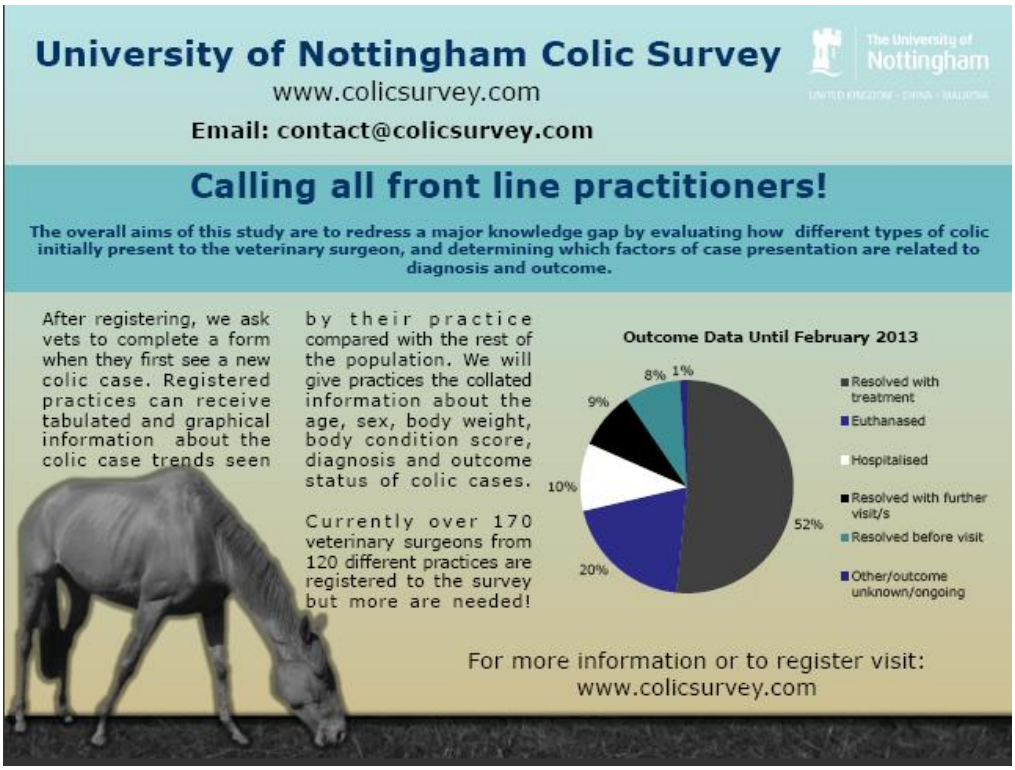
Follow us on:

Taken from http://www.beva.org.uk/news-and-events/news/view/320

Appendix D: Half page advert for the colic survey included in Equine Veterinary Education Volume 25, Issue 5, May 2013



Appendix E: First practice newsletter containing updates and news from the colic survey.

University of Nottingham Colic Survey

Practice Newsletter

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

Issue 1

February 2013

Survey update

- Over 100 vets registered so far
- Almost 250 case forms submitted
- Almost 70 vet practices
- Practices in India, Hong Kong and Germany also registered
- Data so far shows 21% of cases are euthanased

Top 10 Form Fillers

Kathryn Tuckett –Culverden Vets	1st
BE2	2nd
SiHo1	3rd
Simon Turner—Chine House Vets	4th
Caroline Foalks-Aireworth Vets	5th
WeOv1	6th
John Dickerson—Chine House Vets	7th
N.Chapman—Rase Vets	8th
Roger Scammel—Milton Equine	9th
Abigail Kent—Rase Vets	10th

Practice Feedback

The University of Nottingham Colic Survey would like to give something back to those veterinary practices that have supported us by submitting colic case forms. Either with a personal visit or via email, you can receive tabulated and graphical information about the colic case trends seen by your practice compared to the rest of the population. We will give you the collated information about the age, sex, body weight, body condition score, diagnosis and outcome status of colic cases.

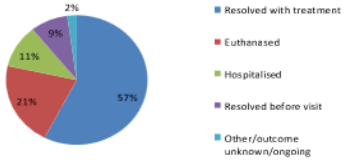
For those of you who are getting competitive with colleagues within your practice, we can also provide a breakdown of the form filling performance of each registered member of the practice!

This information is intended to contribute to the practice audit and clinical governance. Therefore for the information to be valuable (both on an individual and population level), a substantial number of forms must be submitted. Each practice must send at least 20 forms to allow feedback.

So if possible - encourage more vets within your practice to register. Make it a goal for each vet to complete at least 10 forms; this will not only allow us to reach the overall number of forms we require, but permit us to give your practice some useful feedback.

At least 20 forms needed for feedback

Outcome Data until Jan 2013



Overall population data (e.g. outcome) is one section of the feedback available, but we can also provide practice-specific data for many other variables.

Is your practice logo on our website? If not—let us know!

Colic survey receives support from Boehringer Ingelheim

Boehringer Ingelheim, manufacturer of Buscopan, is launching another series of free webinars for equine vets, after the success of their online seminars last summer. Their purpose is to "educate veterinary professionals on up-to-date thinking on a range of practical topics". They have kindly agreed to promote the University of Nottingham colic survey within these webinars which are to take place on 27th February, 6th and 13th March at 8:00pm.

An iPad for a lucky colic survey participant!

Boehringer territory managers will also be taking information about the colic survey on their visits to vets across the country. We hope this will lead a boost to interest, registrations and most importantly, case forms!

Their final supportive venture is to hold a prize draw to win an iPad!

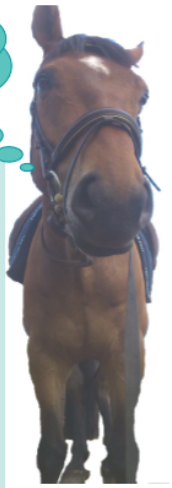
See the colic survey website for terms and conditions. To register for the webinars, visit: www.bi-academy.co.uk

Email: Contact@colicsurvey.com

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

School of Veterinary Medicine and Science,
University of Nottingham
College Road
Sutton Bonington
Leicestershire
LE12 5RD

www.colicsurvey.com
How many forms have **you** submitted??



The plan of action...

The overall aims of this study are to redress a major knowledge gap by evaluating how different types of colic initially present to the veterinary surgeon, and determining which factors of case presentation are related to diagnosis and outcome. There are several phases to this project; the first and most crucial is the current phase of collecting evidence from practice.

The second phase will involve an online questionnaire to evaluate vets' approach to colic in terms of the vet's experience, number and type of cases seen, their preferred approach to colic cases, and any factors that may limit their diagnostic approach. The outcome of the first two phases will then be presented to a group of veterinary surgeons to review and deliberate the results (Delphi technique). Eventually it is hoped that consensus can be reached on best-practice guidelines for the approach to colic in horses.

We hope that you will stay with us throughout all phases of the study- we need the expertise and opinion of vets to review outcomes and implement guidelines that are realistic and effective. You can opt out at any stage but we intend to continue to keep all of those who have contributed updated with study progress throughout all stages.

Make it your goal to complete 10 case forms!

Clinical Commentary

The survey is part of a range of ongoing colic research being carried out at UoN Vet School. Two of our students have just completed their 3rd year research project using colic survey data and have been with the survey from the very beginning. After the successful completion of their projects, Tom is looking to return to the team this summer for 6 weeks to assist with our next systematic review on colic diagnosis. Marise is hoping to head to Morocco to work with SPANA and do some colic research. Both are excellent prospects for colic research and an asset to the team!

As mentioned before we are planning two systematic reviews looking at colic risk factors and diagnosis respectively. Systematic reviews are the gold standard of evidence for clinicians, providing a systematic analysis of the currently available evidence. The first review into risk factors for colic is well underway so watch this space!

Finally, two members of the colic survey team (Dr Sarah Freeman and Laila Issaoui) have written a clinical commentary on colic diagnosis. This article is due to be published in one of the upcoming issue of Equine Veterinary Education, so keep an eye out for that!

University of Nottingham Colic Survey would like to take this opportunity to thank Petplan Charitable Trust for their support of this project.

Survey Support

www.colicsurvey.com

Appendix F: Anonymised example of practice feedback

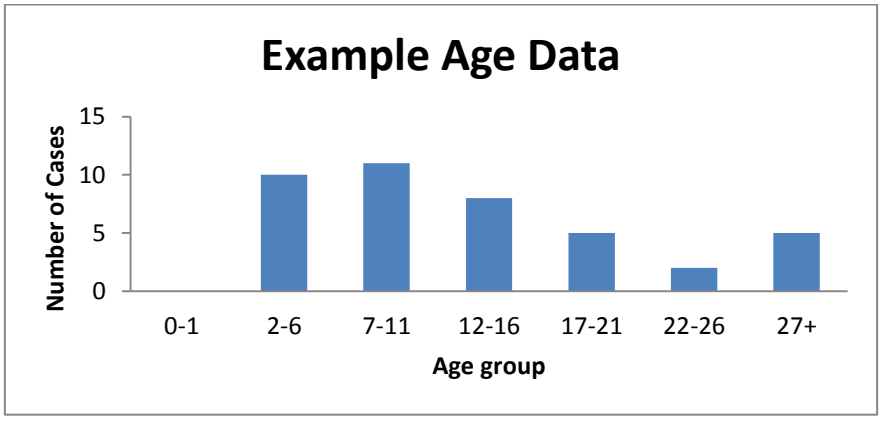
Colic case information for:

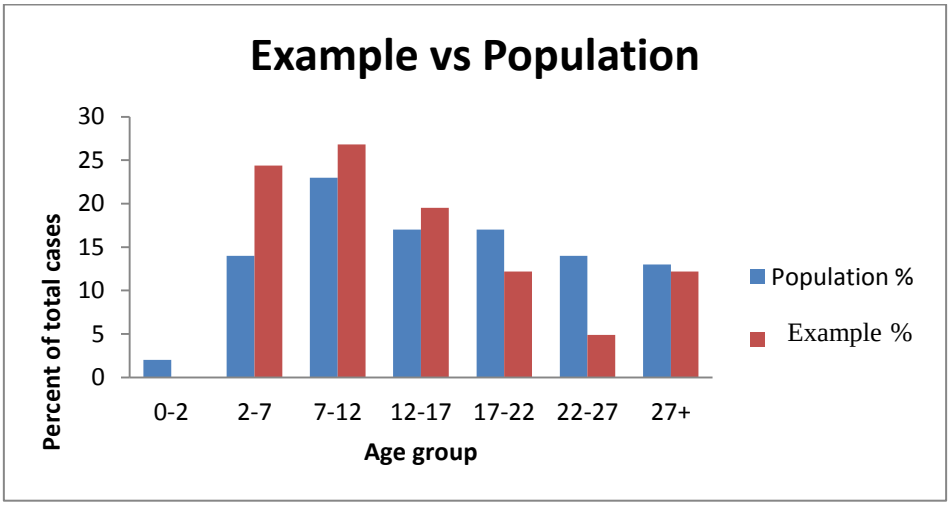
Example Veterinary Centre

Case data provided from 5th December 2012 until 15th February 2013

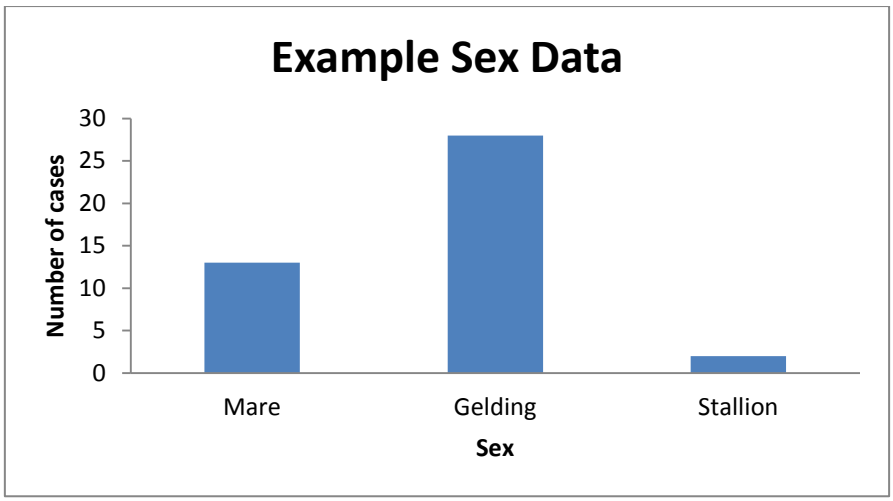
Age

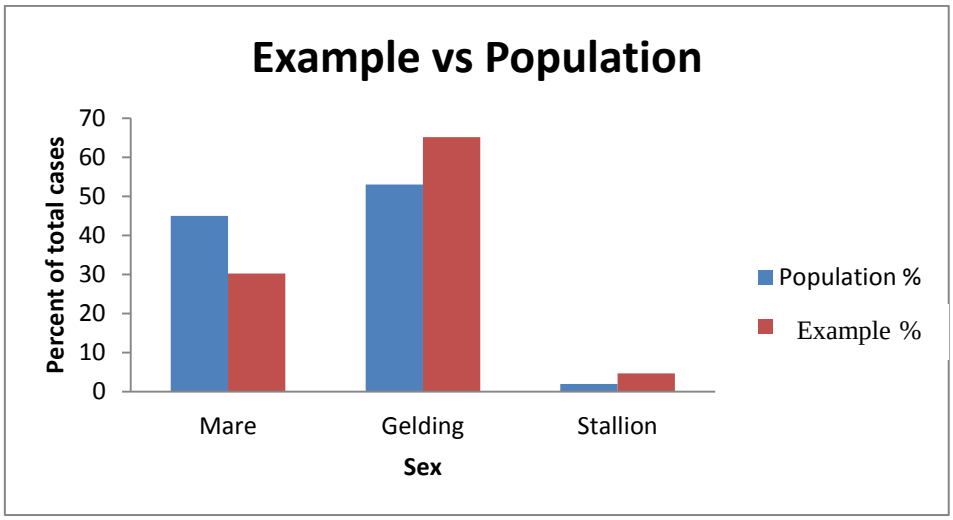
	0-1	2-6	7-11	12-16	17-21	22-26	27+	Total
	0	10	11	8	5	2	5	41
Example %	0.0	24.4	26.8	19.5	12.2	4.9	12.2	100.0
Population %	1.6	14.2	23.2	17.4	17.4	13.7	12.6	100.0



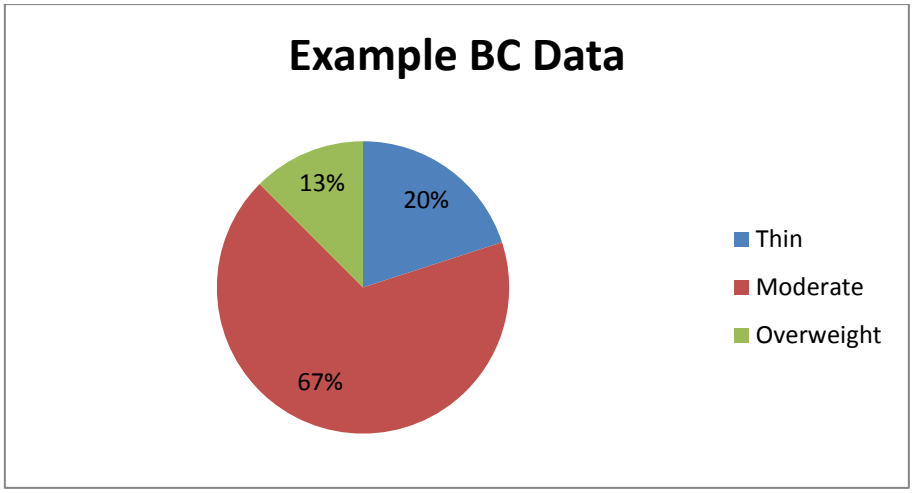


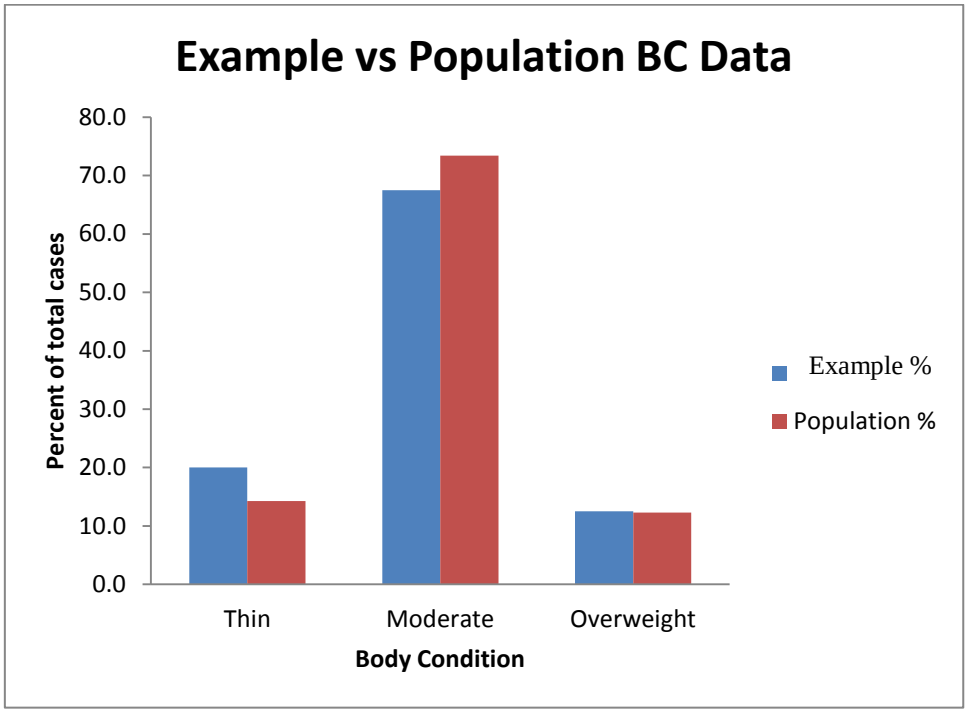
	Sex			
	Mare	Gelding	Stallion	Total
	13	28	2	43
Example %	30.2	65.1	4.7	100
Population %	45.0	53.0	2.0	100





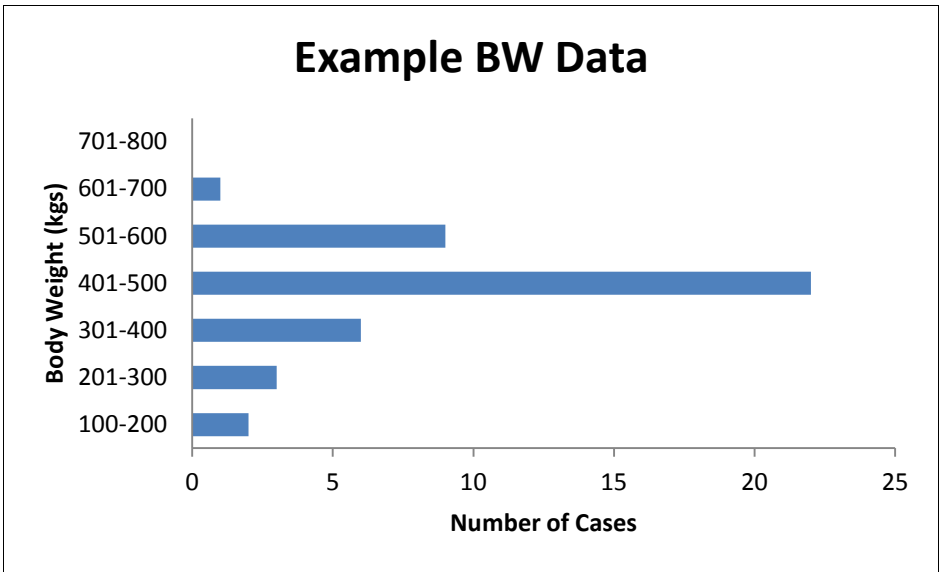
	Body Condition			
	Thin	Moderate	Overweight	Total
	8	27	5	40
Example %	20.0	67.5	12.5	100.0
Population %	14.3	73.4	12.3	100.0

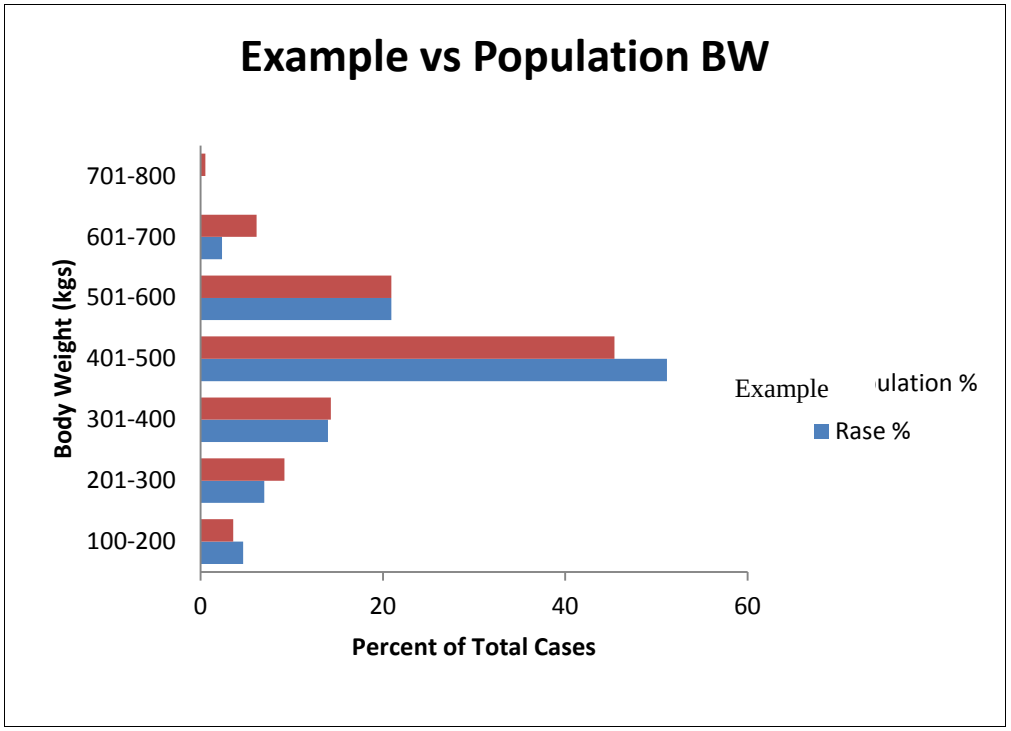




Body Weight (kgs)

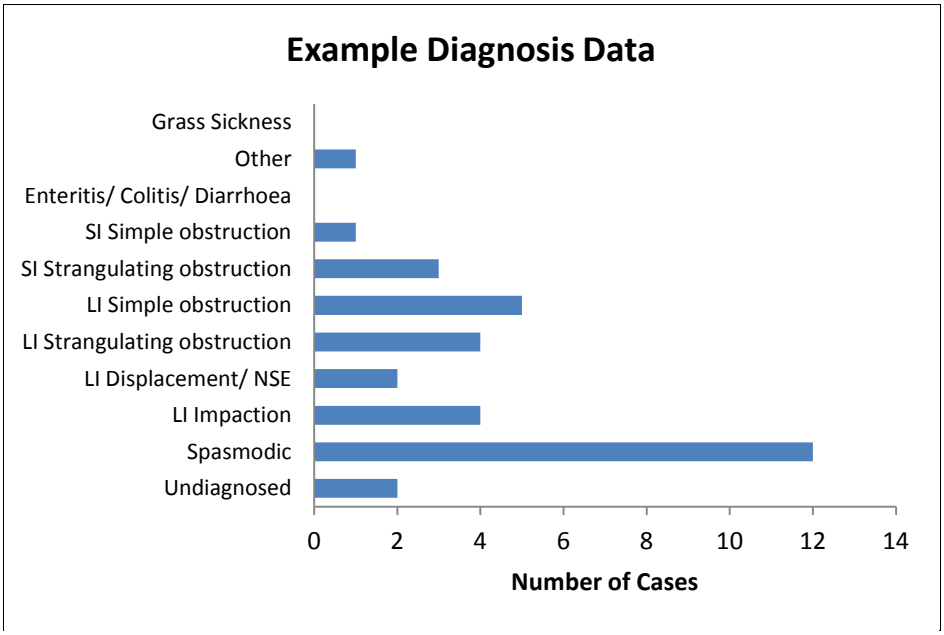
	100-200	201-300	301-400	401-500	501-600	601-700	701-800	Total
	2	3	6	22	9	1	0	43
Example %	4.7	7.0	14.0	51.2	20.9	2.3	0.0	100.0
Population %	3.6	9.2	14.3	45.4	20.9	6.1	0.5	100.0

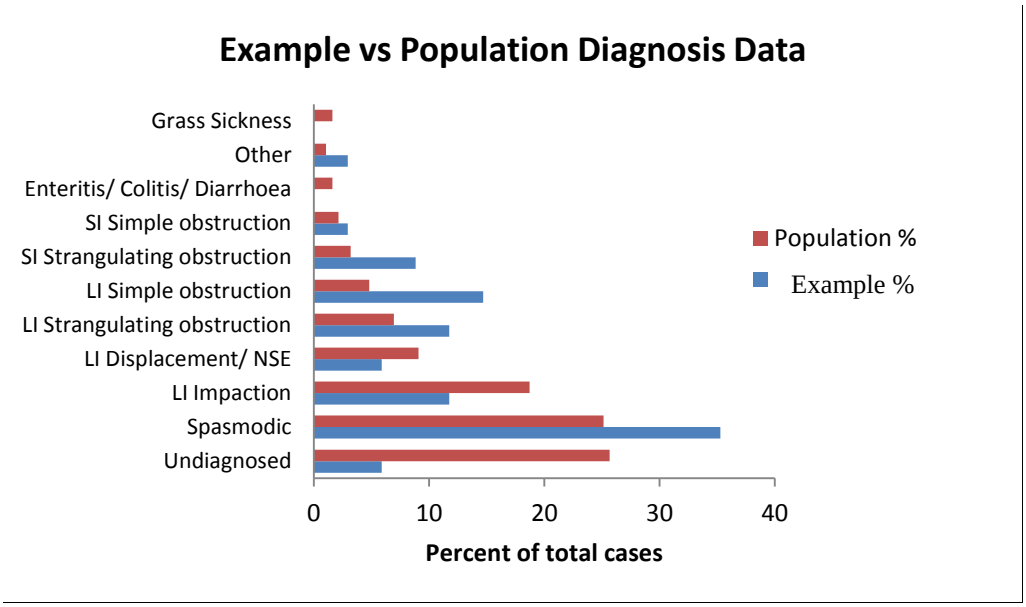




Presumptive Diagnosis

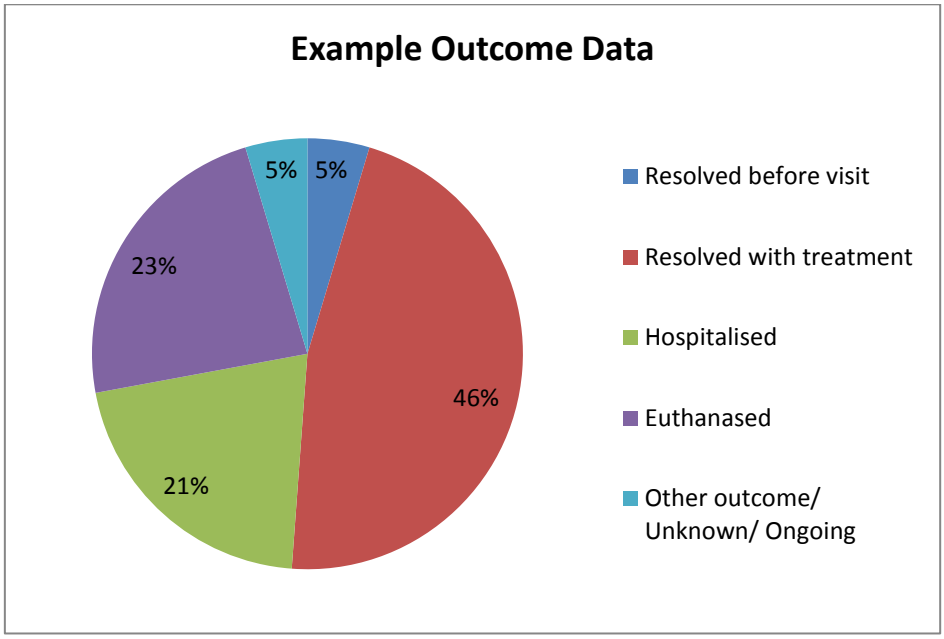
	Undiagnosed	Spasmodic	LI Impaction	LI Displacement/ NSE	LI Strangulating obstruction	LI Simple obstruction	SI Strangulating obstruction	SI Simple obstruction	Enteritis/ Colitis/ Diarrhoea	Other	Grass Sickness	Total
	2	12	4	2	4	5	3	1	0	1	0	34
Example %	5.9	35.3	11.8	5.9	11.8	14.7	8.8	2.9	0.0	2.9	0.0	100.0
Population %	25.7	25.1	18.7	9.1	7.0	4.8	3.2	2.1	1.6	1.1	1.6	100

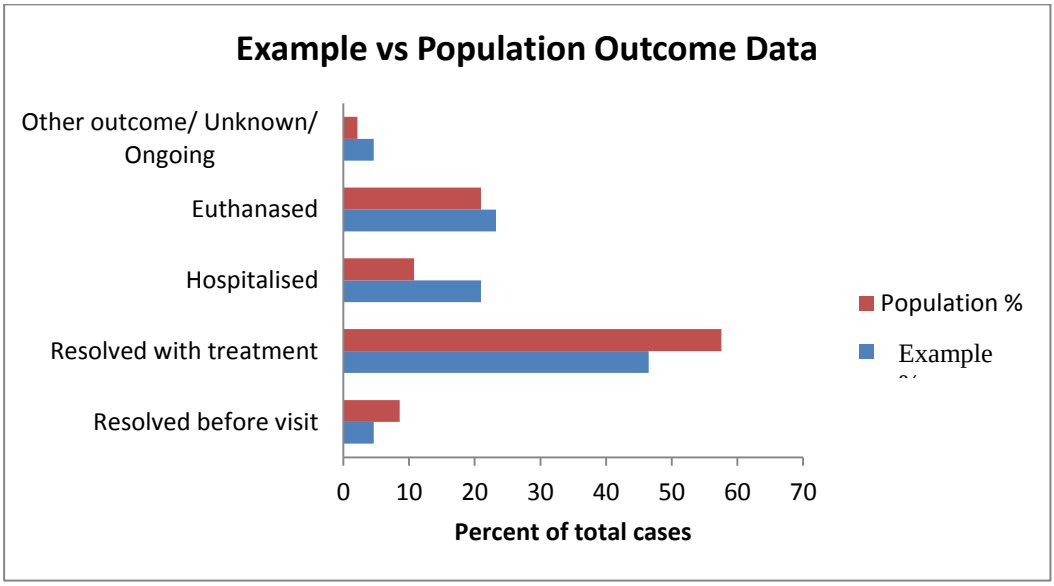




Outcome

	Resolved before visit	Resolved with treatment	Hospit-alised	Euthanased	Other outcome/ Unknown /Ongoing	Total
	2	20	9	10	2	43
Example %	4.7	46.5	20.9	23.3	4.7	100.0
Population %	8.6	57.5	10.8	21.0	2.2	100.0





Appendix G: Second practice newsletter containing updates and news from the colic survey.

University of Nottingham Colic Survey

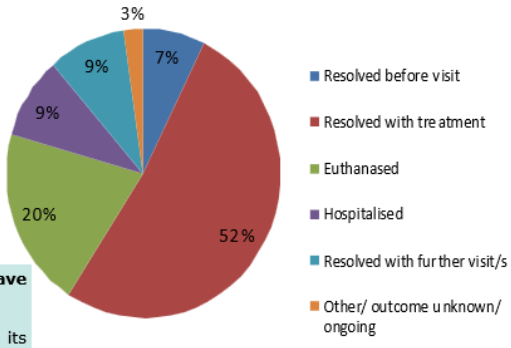
Practice Newsletter

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Issue 2
August 2013

www.colicsurvey.com
How many forms have **you** submitted??

Straight from the horse's mouth



Outcome data from the University of Nottingham colic survey between Sept 2012-August 2013

What the colic team have been up to:

The colic survey is now in its 10th month, and currently hope to meet our target numbers for Nov 2013. Many thanks all participants, please keep submitting cases in our final push. In November, we will do our final analysis, and send full details around to everyone again.

We are part way through our systematic review of risk factors of colic, which has made interesting reading- the results are not always what we expected so we hope that you will find them interesting as well. The systematic review of prognostic tests for colic is also now underway, and we hope that both these reviews will give useful information to support evidence-based decision making (without you having to read the large number of papers that we have waded through).

In other news...

The UK will again be hosting the International Colic Symposium in Dublin in July 2014 (8-10th). This is a research based conference, purely on colic, and there will also be an open access journal issue linked to the conference - check out http://www.beva.org/news-and-events/colic for more information from BEVA. The Nottingham colic team will be there of course.

BEVA Sept 2013 - Nottingham colic team will also be at BEVA this year. Dr Sarah Freeman and Dr John Burford are speaking / chairing or on the colic panel, and Laila Issaoui will be attending the conference, so come and say hello so we can thank you in person for your contributions to the project.

Boehringer Ingelheim

Boehringer Ingelheim will donate £5 to Redwings Horse Sanctuary for each of their completed Buscopan questionnaires available on our website.
This will also enter you into a prize draw to win an iPad!*

*See the colic survey website for terms and conditions.

Come and visit us at BEVA 2013!

Is your practice logo on our website? If not—let us know!

Email: Contact@colicsurvey.com

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

School of Veterinary Medicine and Science,
University of Nottingham
College Road
Sutton Bonington
Leicestershire
LE12 5RD

Final analysis is on its way in November! Lets have a final push to reach 1000 case forms!

Survey update

- Over 270 vets registered so far
- Over 800 case forms submitted
- Almost 200 vet practices
- Practices from around the globe are registered
- Data so far show that over 50% of cases were resolved after the first visit
- 7% of cases are diagnosed as a pelvic flexure impaction

Who's on the team?

The core colic team is Laila Issaoui, Dr Sarah Freeman, Dr John Burford and Prof. Gary England, but we have had some fantastic students helping us throughout. Third year students, Marise Curran and Tom Bayes were involved at the start of the project; both have remained involved since. Tom has recently been working on a systematic review with Laila, and Marise has taken the colic survey out to Morocco working with SPANA. Three new third year students will start soon, helping with final data crunching and may be on the other end of any colic emails. They are Kyra Jennings, Isla Trewin and Jennifer Thomas. All our students have been brilliant team members and a huge help to keeping the project rolling.

What's next?

Survey findings will be analysed in November. The second phase will involve an online questionnaire to evaluate vets' approach to colic in terms of their experience, number and type of cases seen, their preferred approach to colic cases, and any factors that may limit their diagnostic approach. The outcome of the first two phases will then be presented to a group of veterinary surgeons to review and deliberate the results (Delphi technique). Eventually it is hoped that consensus can be reached on best-practice guidelines for the approach to colic in horses.
We hope you will continue to be involved in the next stages!

Top 10 Form Fillers !!

CH3	1st
RaSe9	2nd
BE2	3rd
RaSe8	4th
SiHo1	4th
CU1	6th
RaSe7	7th
WeOv1	8th
CaEq1	9th
MiTo1	10t

University of Nottingham Colic Survey would like to take this opportunity to thank Petplan Charitable Trust for their support of this project.

Petplan CHARITABLE TRUST

Survey Support

www.colicsurvey.com

Appendix H: Third practice newsletter containing updates and news from the colic survey.

University of Nottingham Colic Survey

Practice Newsletter

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Issue 3
December 2013

Survey Stats

- 1021 first opinion only colic case forms submitted
- 289 vets registered
- 188 veterinary practices—178 in UK and Ireland (see below)

Courtesy of Google Maps, GeoBasis-DE/BKG (2013)

Top 10 Form Fillers

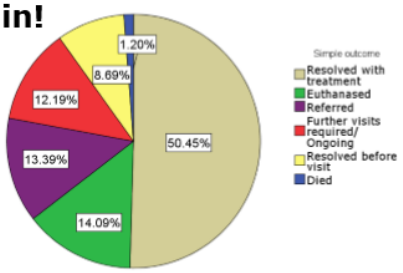
Rase Vets	1st
Scarsdale	2nd
Chine House	3rd
Westover	4th
Bell Equine	5th
Struthers & Scott	6th
Hong Kong	7th
Swale Vets	8th
Simply Horses	9th
Castle Vets	10th=
Culverden Vets	10th=

The results are in!

The colic survey is now closed and we have been busy preparing the data from each case form to be analysed. We are still working on the fancy stats, but here is a snapshot of what the survey has shown us so far.

From September 2012-October 2013, 1064 colic case forms were submitted of which 1021 were first opinion only. The population consisted of 55.2% geldings, 41.5% mares and 3.4% stallions with a mean age of 13.5 (range 0-42) years.

Mean heart rate of cases which resolved at first visit was 43 bpm (range 18-120) and 65 bpm (range 21-125) for euthanased cases. On a colic behavioural severity scale of 0-17, 70.4% scored 1-6 and 29.6% scored 7-12.



Outcome data from the University of Nottingham colic survey between Sept 2012-October 2013

Spasmodic colic (35.9%) and SCOD (18.5%) were the most common initial diagnoses, whilst 16.2% of cases were classified as 'undiagnosed'. 50.4% of cases resolved with treatment at first visit, 14.1% were euthanased. Out of the 13.4% referrals, 1.8% went to surgery, 1.4% were euthanased, 4.5% resolved medically and 5.5% are ongoing/ outcome unknown.

During initial exam, heart rate was checked in 99.2% of cases and rectal temperature in 81.3% of cases. 74.1% of vets performed a rectal exam, 34.3% carried out nasogastric intubation, 17.1% took a blood sample and 6.9% carried out abdominocentesis.

And the winner is...

Boehringer Ingelheim, manufacturer of Buscopan, held a prize draw to win an Apple iPad with Retina display—exclusively for University of Nottingham Colic Survey participants! We can confirm that the lucky winner is...**Rachael Gregson** from **D S McGregor and Partners**. Congratulations **Rachael!**

Boehringer Ingelheim also promised to donate £5 to Redwings Horse Sanctuary for every completed prize draw questionnaire. We are very pleased to announce that **£600** was raised for the equine charity. Thank you to all those who completed questionnaires and helped to raise this donation from Boehringer Ingelheim!

Email: Contact@colicsurvey.com
Web: www.colicsurvey.com

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

School of Veterinary Medicine and Science,
University of Nottingham
College Road
Sutton Bonington
Leicestershire
LE12 5RD

Thanks for all your support—please stick with us till the end!

The plan of action...

The overall aims of this study are to redress a major knowledge gap by evaluating how different types of colic initially present to the veterinary surgeon, and determining which factors of case presentation are related to diagnosis and outcome. 2 out of 3 phases are now complete; the first is the recently completed phase of collecting evidence from practice. The second phase involved a questionnaire evaluating vets' approach to colic in terms of experience, number and type of cases seen, their preferred approach to colic cases, and any factors that may limit their diagnostic approach. The outcome of the first two phases will be presented to a group of veterinary surgeons to review and deliberate the results (Delphi technique) over the next year. This will involve a workshop to develop statements summarising the evidence, then these will be emailed or posted out to vets willing to be Delphi participants to vote on whether they agree or not with each statement.

We will be inviting people to assist with both these phases, and we would love as many people as possible to continue to be involved, and therefore have an active role and say in the outcomes of the project. Eventually it is hoped that consensus can be reached on best-practice guidelines for the approach to colic in horses.

Look out for us at the Equine Colic Research Symposium, Dublin 8-10 July, 2014

Extra findings from the survey

A deeper look into a few specific areas of the colic survey data.

Kyra's Project: 120 LI impaction cases were selected and studied: there were 63 simple medical cases, 44 complicated medical and 11 critical cases. 22 horses had had increased stabling and 14 had had a recent change in diet. Mean heart rate (HR) was 43bpm (26-88bpm), 68% of horses showed mild signs of pain and gut sounds were reduced in 76% of horses. HR was increased and gut sounds decreased more in critical cases. NSAIDs (93%) and oral fluids (71%) were most frequently administered for treatment of the impaction, with **52 different treatment combinations being used,** NSAIDs and oral fluids the most frequent combination. Fifty-one horses (43%) in this study were reported to never be ridden.

Jen's Project: 240 critical cases vs 535 controls. Significant differences in age, signs of pain and clinical variables (HR, CRT, mucous membrane colour, gut sounds) between critical and control populations ($P<0.05$). Rectal exam was not performed in 17.5% of critical cases and nasogastric intubation was not performed in 52.6% of critical cases. Reasons included lack of facilities/resources, co-operation/size/ position of the patient, severe clinical presentation, age of horse, and decision to refer immediately. Of course, it is not always appropriate to carry out such tests, but it is was surprising to see that in some cases, horses were euthanased without these tests which are recommended in all the major texts.

Isla's Project: A mixed methods questionnaire gathered info on survey participant demographics, opinion of the importance of specific diagnostic tests, use of tests and the scenarios in which they were considered most beneficial, and factors which prevent diagnostic tests usage. 209 responses were received. Most practitioners felt confident when managing a colic case and did not require further diagnostic tests to establish a diagnosis. Rectal exam was rated as the most important diagnostic test; however, diagnostic approaches differed greatly, with practitioner employment being significantly influential to the confidence of veterinary practitioners.

University of Nottingham Colic Survey would like to thank Petplan Charitable Trust for their support.

Appendix I: Practice newsletter with colic survey result information and details about multi-disciplinary workshops

Nottingham Colic Project

Practice Newsletter

Email: Contact@colicsurvey.com

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

Issue 4

October 2014

Plan of action

Gather all the research and important findings on colic

Bring together representatives of the equine world - vets, owners, charities, associations and other stakeholders

Host 2 workshops—one about recognising colic, another about diagnostic approach to colic

The workshops will generate statements based on the conclusions of group discussion and research evidence

The statements are repeatedly reviewed confidentially by stakeholders until consensus is reached on as many statements as possible. This is called a Delphi process

The consensus statements will then be disseminated to veterinary organisations and horse owners/carers and their impact measured

Colic project results

Following the completion of the 13 month colic survey, the colic project team have been busy disseminating results and forging ahead with further research plans (see left). In terms of published work, we have one article freely available through BMC Veterinary Research (see link below*) and a further article under review with results of the colic survey.

The BMC article is already highly accessed and currently ranked 11th out of almost 500 articles for the journal. This article has also been picked up by equine lay press around the world (Horse and Hound, Horse talk NZ and Equus magazine).

We have a systematic review of risk factors for colic almost ready to submit following a great response to its presentation at BEVA Congress in September. We are also preparing to submit the results of a vet survey about decision-making in colic which was carried out alongside the main colic survey. The colic project team is currently undertaking two more systematic reviews on diagnostic tests for colic and we look forward to combining the results of these to our growing body of research. We have been working hard to disseminate the outcomes of the colic survey and the systematic review and so far this year have given oral and poster presentations at:

- International Colic Symposium in Dublin
- BEVA Congress in Manchester
- International EBVM Network Conference hosted by RCVS Knowledge in Windsor
- XXXVII Veterinary Medicine Student Congress in Lisbon, Portugal.

Additionally the project team is carrying out a horse owner focussed colic survey which attained 2306 responses! Analysis currently underway— more info on our website!

We encourage as many people to be involved in the project, we want and value your opinions and input on the evidence and outcomes. **Check the website to see how you can help!**

*http://ww.biomedcentral.com/1746-6148/10/S1/S2

Colic Workshop Aim and Objectives

Aim: To improve the recognition of equine colic to help horse owners/carers and veterinary professionals to work together to improve the diagnosis of equine colic.

Objectives: 1) To generate a list of common clinical signs of colic in the horse.
2) To identify which clinical signs are associated with critical cases.
3) To generate a list of important information for a vet to collect on initial exam of colic.

Colic workshops receive support from WHW

World Horse Welfare is an international horse charity that improves the lives of horses in the UK and around the world through education, campaigning and hands-on care. The Nottingham colic project is fortunate to have the support of WHW as we embark on research workshops and Delphi process. More info about the charity can be found at: www.worldhorsewelfare.org

University of Nottingham Colic Project would like to take this opportunity to thank Petplan Charitable Trust for their support of the colic survey

Survey Support

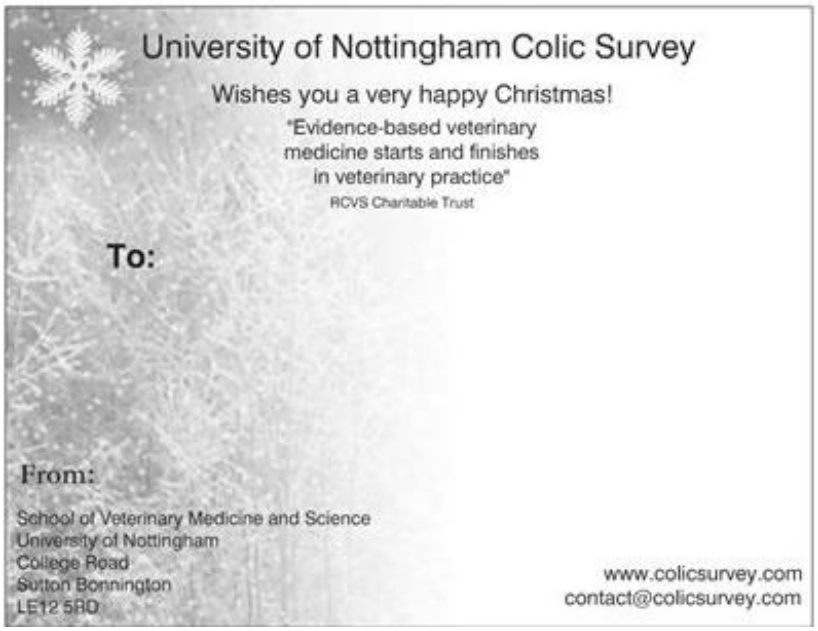
Nottingham Equine Colic Project

@Notts_Eq_Colic

www.colicsurvey.com

Appendix J: Christmas postcards sent to registered practices of the colic survey.

Postcards: Reverse side



Appendix K: Online questionnaire used in a survey of veterinary practitioner' opinions of diagnostic tests used in the primary evaluation of equine abdominal pain

Diagnostic assessment of a colic case

My name is Isla Trewin; I am a third year veterinary student at the School of Veterinary Medicine and Science at the University of Nottingham.
I am conducting a research project which aims to evaluate vets' opinions and attitudes towards the primary assessment of colic and the factors associated with the selection of diagnostic tests.
Colic is described as abdominal pain and in this questionnaire we will only be looking at the evaluation of gastrointestinal colic.
I would be very grateful if you could help me by completing this survey.

If you are willing to take part please read and complete the following consent section.

- ☐ I understand that the information I provide will be confidential and anonymised and that I can withdraw at any stage of the study.
- ☐ I agree to take part in the study and for the data arising from this to be recorded and published for research purposes.
- ☐ I understand that the original data will be stored at the University of Nottingham and only the researcher or supervisor will have access to it.
- ☐ I understand that I can contact the researcher or supervisor with any queries I may have or if I require additional information about the research.

Contact details:

Researcher: Isla Trewin
Email - svyit@nottingham.ac.uk

Supervisor: Dr Sarah Freeman
Email - svzslf@nottingham.ac.uk

Which year did you graduate from University?

Please estimate how many cases of colic you would see on average per month?

Please indicate how confident you are treating a colic case (0- not confident, 5 - very confident)

What type of practice are you employed by currently?

- ◯ Mixed practice
- ◯ Equine practice - first opinion only
- ◯ Equine practice - first and second opinion
- ◯ Equine referral only
- ◯ Other

If you have selected other please state

Please indicate where you are based

- ◯ UK
- ◯ Other

Please list any further qualifications you have achieved since graduation

---

Diagnostic Tests

Please rank the diagnostic tests in order of importance when assessing a critical case of colic (1 - most important, 6 - least important)

	1	2	3	4	5	6
Rectal examination	◯	◯	◯	◯	◯	◯
Abdominocentesis	◯	◯	◯	◯	◯	◯
Nasogastric intubation	◯	◯	◯	◯	◯	◯
Haematology and biochemistry	◯	◯	◯	◯	◯	◯
Ultrasound	◯	◯	◯	◯	◯	◯
Response to analgesia/treatment	◯	◯	◯	◯	◯	◯

Please list any other diagnostic tests that you would use to evaluate a case of colic that have not already been mentioned above.

Please list any other diagnostic tests that you currently do not use but think would be valuable in the assessment of a colic.
Please explain why you are not or cannot use them.

Clinical Decision Making

The following section will focus on the diagnostic tests used to assess a primary case of colic. Our aim is to get a better understanding of what the limitations are behind the use of certain diagnostic tests.

Rectal examination

Please estimate what percentage of cases you would perform a rectal examination in?

Under what scenario would you find the rectal examination the most useful diagnostic test?

We would like to know more about the cases where you decide not to use this diagnostic test.

Please could you select the 3 main reasons why you might choose not to perform a rectal examination (Ranked 1 to 3 - **1 being the most common reason why you would not use this test**)

Reason ranked number 1

If you have chosen "other" as an option please describe further

Reason ranked number 2

If you have chosen "other" as an option please describe further

Reason ranked number 3

If you have chosen "other" as an option please describe further

---

Abdominocentesis

Please estimate what percentage of cases you would perform abdominocentesis in?

Under what scenario would you find abdominocentesis the most useful diagnostic test?

We would like to know more about the cases where you decide not to use this diagnostic test.

Please could you select the 3 main reasons why you might choose not to perform abdominocentesis (Ranked 1 to 3 - **1 being the most common reason why you would not use this test**)

Reason ranked number 1

If you have chosen "other" as an option please describe further

Reason ranked number 2

If you have chosen "other" as an option please describe further

Reason ranked number 3

If you have chosen "other" as an option please describe further

---

Nasogastric intubation

Please estimate what percentage of cases you would perform nasogastric intubation in?

Under what scenario would you find nasogastric intubation the most useful diagnostic test?

We would like to know more about the cases where you decide not to use this diagnostic test.

Please could you select the 3 main reasons why you might choose not to perform nasogastric intubation (Ranked 1 to 3 - **1 being the most common reason why you would not use this test**)

Reason ranked number 1

If you have chosen "other" as an option please describe further

Reason ranked number 2

If you have chosen "other" as an option please describe further

Reason ranked number 3

If you have chosen "other" as an option please describe further

---

Haematology and biochemistry

Please estimate what percentage of cases you would perform haematology and biochemistry in?

Under what scenario would you find haematology and biochemistry the most useful diagnostic test?

We would like to know more about the cases where you decide not to use this diagnostic test.

Please could you select the 3 main reasons why you might choose not to perform haematology and biochemistry (Ranked 1 to 3 - **1 being the most common reason why you would not use this test**)

Reason ranked number 1

If you have chosen "other" as an option please describe further

Reason ranked number 2

If you have chosen "other" as an option please describe further

Reason ranked number 3

If you have chosen "other" as an option please describe further

---

Ultrasound

Please estimate what percentage of cases you would perform ultrasound in?

Under what scenario would you find ultrasound the most useful diagnostic test?

We would like to know more about the cases where you decide not to use this diagnostic test.

Please could you select the 3 main reasons why you might choose not to perform an ultrasound examination (Ranked 1 to 3 - **1 being the most common reason why you would not use this test**)

Reason ranked number 1

If you have chosen "other" as an option please describe further

Reason ranked number 2

If you have chosen "other" as an option please describe further

Reason ranked number 3

If you have chosen "other" as an option please describe further

---

Response to analgesia/treatment

Please estimate what percentage of cases you would use response to analgesia/treatment as a diagnostic tool?

Under what scenario would you find the response to analgesia and treatment the most useful diagnostic test?

We would like to know more about the cases where you decide not to use this diagnostic test.

Please could you select the 3 main reasons why you might choose not to use response to analgesia/treatment as a diagnostic tool (Ranked 1 to 3 - **1 being the most common reason why you would not use this test**)

Reason ranked number 1

If you have chosen "other" as an option please describe further

Reason ranked number 2

If you have chosen "other" as an option please describe further

Reason ranked number 3

If you have chosen "other" as an option please describe further

---

Are there any other diagnostic tests that you would use more frequently than the ones listed above?

- ◯ Yes
- ◯ No

Please state the diagnostic test.

Please estimate what percentage of cases you would use this test as a diagnostic tool?

Under what scenario would you find this diagnostic test the most useful?

We would like to know more about the cases where you decide not to use this diagnostic test.

Please could you select the 3 main reasons why you might choose not to use this specific diagnostic test in the evaluation of a colic (Ranked 1 to 3 - **1 being the most common reason why you would not use this test**)

Reason ranked number 1

If you have chosen "other" as an option please describe further

Reason ranked number 2

If you have chosen "other" as an option please describe further

Reason ranked number 3

If you have chosen "other" as an option please describe further

---

Thank you for completing the survey!

The data you have kindly provided us with will be used to formulate a set of guidelines that will detail the best-practice approach to equine colic.

Please contact us if you have any queries regarding the questionnaire or the research we are conducting.

Contact details:

Researcher: Isla Trewin
Email - svyit@nottingham.ac.uk

Supervisor: Dr Sarah Freeman
Email - svzslf@nottingham.ac.uk

Appendix L: Online questionnaire used to identify horse owners for multi-disciplinary workshops

Horse owner typography

Nottingham Colic Project Horse Owner/Carer Survey

The University of Nottingham Colic Project is looking for a group of horse owners/carers to be involved in an upcoming research workshop on Saturday 22nd November. It is one of two workshops that will bring together a wide range of veterinary professionals, horse charities, organisations and horse owners/carers. The aim of the workshops are to improve the recognition of equine colic to help horse owners/carers and veterinary professionals to work together to improve the diagnosis of equine colic.

This short questionnaire is designed to explore and define the human-horse relationship for each owner/carer, in order to find a range of horse owners with various views on the role of horses in their lives. We then intend to select an equal number of owners from each 'typology' to assist us with the next phase of research.

The method of defining the human-horse relationship was developed by Claire Scantlebury and fellow researchers at the University of Liverpool (you can use the link below to read the research article yourself for free).

http://www.biomedcentral.com/content/pdf/1746-6148-10-S1-S1.pdf

Consent form

The following questionnaire should take about 5 minutes to complete.

Participation in this research is entirely voluntary and there is no obligation to take part. Please note you must be over 18 years of age to take part.

This study has been approved by the School of Veterinary Medicine and Science's ethics committee.

Further information about the study can be obtained by contacting: contact@colicsurvey.com

Many thanks in advance for your help with this study.

Nottingham Colic Project team

Consent:
This consent form is a formal way of indicating that you agree to participate in this study and that you understand that any information collected by the researchers:
- will be used for a research study
- may be written in a report for publication
- may be presented at research conferences or meetings
- will be anonymised and treated confidentially
- will only be accessed by research colleagues or examiners
- that you can request to see a copy/summary of the completed study
- that you can request to see any information written down/kept during the process of data collection.

*1. If you are willing to participate in this study, please complete the following consent section.

*** 1. I have read and understood the relevant information regarding consent and agree to the terms laid out for my participation in this study.**

○ Yes

Horse owner typography

Contact details and availability

Once we have selected a balanced range of owners/carers from this questionnaire we will contact them with regards to their involvement in the research workshops. In order for us to do this, please provide your name and email address in the space provided. If you do not have an email address, a telephone number is sufficient. Your contact details will be treated with strictest confidence and only used for the purposes of communicating information about the colic project.
If you do not wish to provide your contact details, your participation in this questionnaire is no longer required.

*** 2. Email address**

3. Please let us know which stages you can be available for (please tick all that apply)

	Yes	No	Not sure
Workshop 1 - 22nd November at Sutton Bonington	○	○	○
Workshop 2 - 31st January at Sutton Bonington	○	○	○
Delphi - online in February (date to be confirmed)	○	○	○

Prev Next

Horse owner typography

Demographics and Personal Experience

*** 4. Thinking about colic in the horse, how many different episodes have you personally seen?**

- ○ None
- ○ 1-2
- ○ 3-4
- ○ 5-7
- ○ 8-10
- ○ 11-20
- ○ 21-30
- ○ 30+

*** 5. How confident would you be that you could recognise colic in a horse?**

- ○ I would recognise every case in different horses with different personalities and severities
- ○ I would recognise most cases unless it was a very odd presentation or an unfamiliar horse
- ○ I would recognise it in some cases but not in all cases/ severities
- ○ I wouldn't recognise it unless it was very severe/ obvious
- ○ I wouldn't recognise it at all

*** 6. In which region to you currently live?**

- UK North
- UK North East
- UK North West
- UK Yorkshire and Humberside
- UK East Midlands
- UK Wales
- UK West Midlands
- UK East Anglia
- UK South West
- UK London
- UK South East
- UK Northern Ireland
- Isle of Man
- Other (please specify)

7. Which age range do you fit in?

- Under 18 years
- 18-30 years
- 30-40 years
- 40-50 years
- 50-60 years
- 60-70 years
- Above 70 years

Horse owner typography

Human-horse relationship

8. Please indicate along the scale how you view your horses.

	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree
"I consider my horse/pony to be a pet"	○	○	○	○	○
"I consider my horses/ponies to be working animals"	○	○	○	○	○
"Working with horses is part of my profession"	○	○	○	○	○

9. For each of the categories below, please indicate along the scale where your place yourself as a horseman/horsewoman and your relationship with horses.

	Disagree strongly 1	2	3	4	5	6	7	8	9	Agree strongly 10
"I keep my horse for a sense of achievement (e.g. bringing on a youngster, becoming an accomplished rider etc)"	○	○	○	○	○	○	○	○	○	○
"I keep horses for the satisfaction gained from the relationship I have with my horse"	○	○	○	○	○	○	○	○	○	○
"I keep horses in order to compete and win"	○	○	○	○	○	○	○	○	○	○

Thank you!

Your participation in this survey is very much appreciated.
If you are one of the respondents selected to be involved in the workshop on 22nd November we will contact you as soon as possible using the details you have provided.

Further information about the Nottingham Colic Project can be found at www.colicsurvey.com.
Should you have any questions, please contact us at contact@colicsurvey.com

Prev Done

Appendix M: Description of owner typologies used to categorise owners into categories for multi-disciplinary workshops

Cluster number	Cluster name	Description
1	**Competing professional** n=136	**Professionals** predominantly saw their horses as working animals. This group reported a sense of achievement and satisfaction from their relationship with their horse, and competing and winning was often quite important to them. Many, but not all, felt their horse was also a pet.
2	**All round amateur** n=209	**Amateurs** their horses were reported as pets and they got a strong sense of satisfaction from their relationship with the horse, and a moderate sense of achievement. Sport tended not to be important and they strongly disagreed that their horses were working animals.
3	**Non-competing professional** n=46	**Professionals** differed from cluster 1 in that they strongly disagreed that competing and winning was important and disagreed that their horse was a working animal. They still felt their horses were pets and got a lot of satisfaction from their relationship with the horse, but had less sense of achievement from keeping horses.
4	**Friend/ Companion** n=87	**Amateurs** reported their horses were pets with which they strongly relate. Sport was not important, and their horse was not a working animal and they did not report a sense of achievement from owning the horse.
5	**Competing amateurs** n=145	**Amateurs** who competed and frequently saw their horses as working animals. Owning horses provided a sense of achievement and their relationship with the horse was moderately important.

Scantlebury *et al. BMC Veterinary Research* 2014 **10**(Suppl 1):S1 doi:10.1186/1746-6148-10-S1-S1

Appendix N: Form used to gain consent from participants at multi-disciplinary workshops

School of Veterinary Medicine and Science

Consent form – Nottingham Colic Project Workshops *You must complete this form in order to participate in the workshops

Participation in this research is entirely voluntary and there is no obligation to take part. Please note you must be over 18 years of age to take participate. This study has been approved by the University of Nottingham, School of Veterinary Medicine and Science Ethics Committee. Further information about the Nottingham Colic Project can be obtained on our website (www.colicsurvey.com) or by contacting the research team at contact@colicsurvey.com.

As a participant in this study you can:

- Request to see a copy/ summary of the completed study
- Request to see any information written down/ kept during the process of data collection

A journalist may be present and reporting on the workshop. The reporter is not permitted to release information about the content of discussions, but may ask for general comment. If you do not wish to give comment or give your name, it is your responsibility to inform the reporter.

This consent form is a formal way of indicating that you agree to participate in this study, please read the statements below and tick the boxes to show you agree:

☐ I understand that I am not obliged to give consent and I may withdraw my participation at any point of the process

☐ I understand that my contribution to the study will be recorded and used for research purposes

☐ I understand that the research from this study may be presented at research conferences or meetings

The research team intend to list participants by name in the workshop proceedings. If you DO NOT wish your name to appear in the proceedings, please tick the box

I have read and understood the terms stated above:

Print Name……..

Signature……..

Date…….

Appendix O: Evidence pack sent to participants of multi-disciplinary Workshop Two

WorldHorseWelfare

The University of Nottingham

School of Veterinary Medicine and Science

Nottingham Colic Project Workshop
Saturday 28th February 2015

- Your visit
- What is a Delphi process? Overview of the workshop/Delphi process
- What to expect – Details of the day, aims and objectives
- How to prepare for the workshop
- Critical reading – Interpreting the evidence
- Q&A – A guide for horse owners/ carers
- Contact – What to do if you need help
- Summaries of presentations – Essential reading

This workshop is kindly supported by World Horse Welfare

Sat Nav

The postcode for the Sutton Bonington campus is:**LE12 5RD**

Bus

Bus services run from Nottingham, Loughborough and East Midlands Airport to Sutton Bonington. More information on this service can be found at:
http://www.nottingham.ac.uk/about/visitorinformation/busservices.aspx

Car

From M1 motorway

The M1 motorway has an access point (Junction 24) at Kegworth, 2 miles from the Campus. Persons travelling by road from the North West and South otherwise than by motorway are advised to make for the A6, turning off at either Kegworth or Hathern for Sutton Bonington.

From the south

Go to Leicester via the A6 to Loughborough (12 miles) then from Loughborough via the A6 to Hathern (3 miles). Leaving Hathern via the A6 turn right along the A6006. Pas through Zouch and take the first turning on the left for Sutton Bonington. Pass through Sutton Bonington, follow the main road up the hill and bear left at the top – Sutton Bonington Campus is on the right hand side.

From the north

Nottingham – cross the Clifton Bridge along the Ring Road and get into the correct lane for Birmingham and M1 marked by overhead signs. Follow the A453 via Clifton. Take the first exit to the roundabout and continue along the B679 turning right in Gotham for Kingston-on-Soar (marked "Kingston"). Straight over the mini-roundabout. In Kingston-on-Soar, fork left for Sutton Bonington. Sutton Bonington campus is on the left hand side.

From the north west

From Derby, follow the A6 to the A50 to the roundabout at Junction 24 of the M1. Take the 3rd exit to Kegworth. On the outskirts of Kegworth, take the first turning on the left (signposted "Sutton Bonington"). Follow this road through Kegworth and turn right immediately after the "Anchor Inn". Then turn right at the nest crossroads. Sutton Bonington Campus is on the left.

Those travelling by road from the north west and south by other routes should follow the signposted routes from the A6 at Kegworth or Hathern to Sutton Bonington Campus.

Travel costs for the workshops

World Horse Welfare are kindly supporting these workshops, and this includes assistance with travel costs for those that require this. We can provide reimbursements of travel costs at a rate of 10p/mile, up to a maximum of £45 per person. If you wish to have your travel costs reimbursed from World Horse Welfare, then please complete the enclosed travel reimbursement form and bring it along to the workshop. Alternatively, please return the form to Laila Curtis (Postgraduate), School of Veterinary Medicine and Science, University of Nottingham, College Road, Sutton Bonington, Leicestershire, LE12 5RD. Forms will no longer be accepted after 1st April 2015

What is a Delphi process? Overview of the workshop/Delphi process

A Delphi process is a structured means of developing consensus on a topic through discussion, feedback and agreement amongst individuals with various experiences and expertise, and an understanding of the current research on the topic. The "end product" is a list of statements which can be used to guide to support practitioners (and in this case, owners and carers of horses also). This is the basic overview of the workshop and Delphi process for the Nottingham Colic Project:

- Research and important findings are gathered on first opinion colic.

- This information is presented as an 'evidence pack' to a group of stakeholders with varied interest and experience in the field of the colic. These include veterinary practitioners from a range of types of practice, equine veterinary specialists, horse owners/ carers with various typographies, equine charities, equestrian organisations and other stakeholders.

- When the stakeholders are fully informed of the evidence presented to them, they are brought together for a workshop and placed in small groups. Each group is facilitated by a member of the research team who will guide discussion towards the objectives of the workshop. The first workshop will concentrate on recognising colic whilst the second workshop will focus on the diagnostic approach.

- Each group will generate a set of statements based on the conclusions of group discussion and research evidence.

- The Delphi process involves recruiting a panel of experts to agree on the series of statements. It differs from the workshops in that the participant's identity, responses and feedback are anonymised. Panel members will rank their agreement with the evidence statements produced by the workshops (using a 9 point Likert scale) and provide feedback, particularly for those with which they disagree. A 70% level of consensus will be used to accept statements. Those without consensus will be removed or modified and reissued in a process of 3 rounds to define consensus on the final output of evidence-based guidelines.

There are several advantages of this methodology: it reduces any potential individual bias in interpreting results, it listens to the different voices involved in the decision making process, it continues to engage with practitioners and stake-holders (who have had active involvement in this research), and it facilitates dissemination and implementation of outcomes.

What to Expect?

Details of the day

Tea and coffee and snacks will be served on arrival and during the afternoon. A buffet lunch will be at 1pm and still and sparkling water will be available throughout the day. If you have a particular dietary requirement, please let us know.

10:30–11:00 Arrival, please meet in the Atrium of the Vet School. There will be optional tours of the School of Veterinary Medicine and Science for those that are interested. Alternatively this is an opportunity to meet others participating in the workshops. If you do not wish to join a tour, please arrive by 10:55 at the latest.

11:00-13:00 Presentations will be given of evidence summaries that are provided in this evidence pack as refresher, and to give participants the opportunity to ask questions.

13:00 Lunch

14:00 – 17:30 Participants will be divided in to discussion groups. Each group will have a facilitator to guide the discussion and a note taker.

(16:00 Afternoon break)

17:30 End of workshop

Aims and Objectives

The multi-disciplinary nature of these workshops ensures that the outcomes have a wide relevance and impact on the care and welfare of the horse. Evidence-based guidelines for colic will help owners to recognise clinical signs of colic and when to seek veterinary assistance, and enable veterinary surgeons to identify critical cases as early as possible.

The overall aim of the colic workshops and Delphi process is:

"To improve the recognition of equine colic by helping horse owners/ carers and veterinary professionals to work together to improve the diagnosis of equine colic".

As mentioned earlier, each workshop group will have a facilitator to guide the discussion, ensuring topics don't go off track, and making sure everyone has fair opportunity to be involved in the conversation. The facilitators will target discussions towards meeting the workshop objectives which are:

- To describe the physical examination approach for the first assessment of a horse with colic
- To describe the diagnostic approach for the first assessment of a horse with colic
- To identify where further education / training / research is required

How to prepare

In order to participate fully in the colic workshops, we would like you to have an understanding of the current evidence available on first opinion colic. This awareness will allow you to contribute an informed opinion to the group discussion in addition to your views and experiences.

Please take your time to read through the short summaries at the end of this booklet. They each present a piece of research in the field of equine colic and will help to supplement your current understanding of the evidence. We will also give presentations on the day summarising key points, and we will have extra information printed out for every group on their table. Your facilitator is also there as a source of 'expert information' so will have a detailed understanding of the information and can help answer any questions you have on this. You just need to come having an understanding of what we are aiming to do and be prepared to get involved and give your perspective.

Some of the evidence provided is brand new research which has not been published yet, therefore please treat the content of the summaries with complete confidentiality.

Essential Reading – found at the end of this booklet

- **Summary 1** – A systematic review of physical parameters used for the primary diagnosis of colic in the horse. Laila Curtis
- **Summary 2** – A systematic review of laboratory tests used for the primary diagnosis of colic in the horse. Tom Cullen
- **Summary 3** – First-line treatment choice and colic survival in the UK: A multi-practice study. Tim Mair
- **Summary 4** - The diagnostic approach of 1016 cases of colic presented to first opinion practitioners, and the differentiation of critical and non-critical cases. Laila Curtis
- **Summary 5** – Trends in management of horses referred for evaluation of colic: 2004-2013. Tim Mair
- **Summary 6 -** Veterinary practitioners' opinions of diagnostic tests for the primary evaluation of colic in the horse. Laila Curtis
- **Summary 7 –** Experiences of half a million rectal examinations. John Newcombe
- **Summary 8 –** Clinical decision making in veterinary practice. Sally Everitt

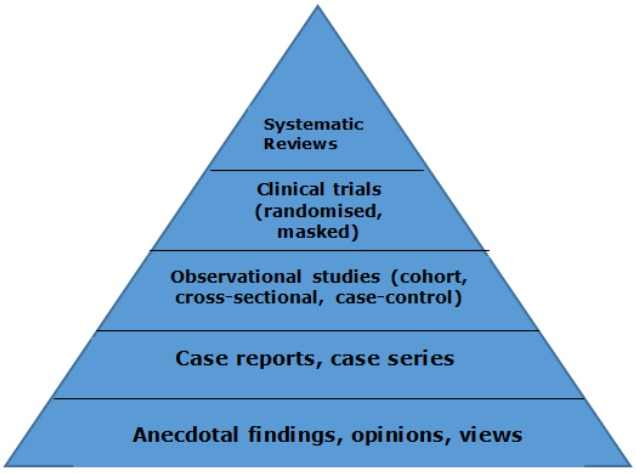
Critical reading – Interpreting the evidence

Evidence-based medicine is about evaluating the current information and scientific research, and using this to make the best decision for an individual patient. It is based on the fact that there may be a lot of different sources of information about particular diseases or topics, and these can vary both in their quality, and in what they recommend. Evidence-based medicine involves weighing up all this information to decide what will provide the best possible care for people or animals. Information and scientific evidence can be of different quality or levels, and the levels of evidence are often described as a triangle.

The diagram below shows a simplified version of this, with the highest levels of evidence being systematic reviews, and the lowest levels being individual opinions and ideas. The highest levels of evidence (systematic reviews) will be the most reliable, as they are drawn from several different studies, and critically appraise the evidence using strict criteria before drawing any conclusions.

So why isn't every research question answered with a clinical trial? Well, firstly each different type of question requires a different type of study to answer that question. For example, to find out what the risk factors are for colic, a clinical trial will not suffice and a cohort study is the preferred method. Case reports and case series are a great starting point for rare or unusual clinical scenarios which can then be used to design a clinical trial. Secondly, funding and a great deal of time is required to carry out large controlled studies, and this is not always readily available, so researchers and practitioners often get the best information they can which may involve using a type of study which sits lower down on the evidence triangle.

The triangle shape reflects the amount of information at each level – there are lots of people with opinions and ideas, but only a small number of systematic reviews which draw together all the evidence. Your facilitator can advise on the level of evidence of different information during the workshop, so you don't need to become an expert on this, but you do need to understand the key principle of why there are different levels and why this is important.



Q & A

Why do you need me to help produce guidelines?

The workshops are about developing information and guidelines to help improve the recognition and diagnosis of colic in the horse. Evidence-based guidelines are used frequently in human medicine to help improve diagnosis or treatment of conditions – you are probably familiar, for example with some of the campaigns to help people recognise the signs of meningitis, or the 'act FAST' campaign for strokes – our vision is to develop these for colic in the horse. The principle behind developing guidelines is very simple – you need to get together the different people who are going to use the information and involve them in deciding what you do with it. Scientists and researchers have a role to play in developing the information and evidence, but the people who will actually use it should have a major role in how this scientific information gets used, and this is where you come in. We will have a range of different people involved in the workshops, including horse owners, vets and organisations involved in the health and welfare of horses. We have chosen people, so that some will have lots of experience, and others will have less – **everyone's opinions and perspective are important**. For example, people that have lots of experience can share this knowledge and experience, and people with little experience can highlight which aspects of diagnosis can be difficult or challenging, different owners will have different opinions on which and how many tests they would want done in their horse. We need to develop guidelines that are practical and useful for everyone, irrespective of their background or experience. We have developed research which looks at how colic is diagnosed – we need you to help us put this research into practical plans to combat this disease in the horse.

What will I have to do on the day?

On the day of the workshop, we will present short summaries of the evidence that is in this booklet, we will then split everyone into small groups with mixed backgrounds and experience, and ask them to discuss it and generate 'statements' around the evidence. We will have a member of the research team guiding each group – they can't generate the statements – this has to come from you, but they can help you, give advice or further information if needed, and will also 'facilitate' the group so that everyone has a say and is listened to. Some of the statements you generate may seem very obvious to you, but remember, not everyone has the same experience, and good guidelines provide practical help for everyone, starting with the essentials. The Meningitis and Stroke campaigns in human health are very good examples of this. It is also important to understand, that guidelines are not rules that must be obeyed – they provide guidance and help, but will need to be considered in the context of each individual horse. During the workshop, you will also find areas that your group agrees on easily, and areas that you disagree on– this is fine – the workshop will also help identify where we don't have enough information yet, and where we need more research. This is just as important as reaching agreement.

Don't be afraid of saying that you don't agree, and don't be afraid of saying you don't understand what someone else/ the group have decided. You are the voice of all the different people involved in caring for horses; if you don't agree or understand, then

other people won't and we need to know! There are a whole range of people, and experts involved, but please do not feel intimidated at any point - everyone's opinion is just as important. This will be one of the first evidence-based workshops for veterinary medicine in the horse – it will probably be quite different to other experiences you have had, but we passionately believe that what we are doing is important and will make a major difference. We really value your involvement and input – this technique is used in human medicine (including our collaborators at the Headsmart campaign for brain tumours in children) – it will make you think about things in a new way, and enable you to help make a difference. And of course, we will provide cakes and refreshments to keep you fuelled on the day!

What do I need to do beforehand?

Before you come, please read the information about the day that we have provided in this booklet. If you have time, please read through the short summaries of the research in the other booklets, but if you don't have time to do this, don't worry. We will give presentations on the day summarising key points, and we will have all this information printed out for every group on their table. Your facilitator is also there as a source of 'expert information' so will have a detailed understanding of the information and can help answer any questions you have on this. You just need to come having an understanding of what we are aiming to do and being prepared to get involved and give your perspective.

Do I have to attend?

If you find that you now can't attend, please let us know as soon as possible.
If you have read the information in the booklet and have any concerns about contributing to the groups, then please do get in touch with us. We hope that we can give you further information and advice to reassure you, but if you wish to withdraw, then you can at any stage.

What happens after the workshops?

After the workshops, we will collect all the statements from each group (there will be lots of groups on the day), and pool these together to generate evidence statements. The next step is to circulate these statements round a larger group of people (using an online questionnaire), who will vote on whether they agree with them or not (Delphi process). The research team will analyse the questionnaire responses, modify, accept or remove each statement depending on responses, and then circulate them again (to a maximum of 3 times) until we reach consensus. Once again, disagreement is fine – it highlights where we need more research or information. We hope that you can see that your involvement in this first stage is critical in starting this process, but there will be lots of people involved in generating and voting on the statements. You can stay involved in the process after the workshops – we can provide email updates for those who wish, and of course, we will also provide project updates on our Facebook page (Nottingham Equine Colic Project) and website (www.colicsurvey.com).

Contact – what to do if you need help

As an invited member to this workshop you can expect to have the full support of the research team should you have any questions. Please do not hesitate to contact us in advance or grab any member of the team on the day to ask advice.

The main research team is:

Laila Curtis

Professor Sarah Freeman

Dr John Burford

Professor Gary England

We will also have assistance on the day from several helpers – researchers and students from the Vet School with name tags. Any of them will be able to point you in the right direction – don't be afraid to ask!

Email: contact@colicsurvey.com

This email address is linked to three of the main researcher's regularly checked emails, so you can expect a response within 24 hours. On the day of the workshop we will have immediate access to emails so will aim to respond as soon as possible.

Emergency Telephone: Security 24 hour – 0115 9513013

If there is an emergency on the day please call security

Summaries of presentations

Summary 1 – A systematic review of physical parameters used for the primary diagnosis of colic in the horse.

L. Curtis, T. Cullen, G.C.W. England, J.H. Burford, and S.L. Freeman
School of Veterinary Medicine and Science, University of Nottingham, College Road, Sutton Bonington, Loughborough, Leicestershire. LE12 5RD

Background: Early identification of surgical cases of colic is critical to improving outcome and welfare. There have been a number of studies on diagnostic tests for colic, evaluating a range of tests to differentiate between medical and surgical cases. *Objectives:* To systematically review and appraise the evidence on diagnostic tests for identifying surgical colics. *Study Design:* Systematic review

Methods: The primary literature search was conducted in CAB Abstracts (1910-2014), WEB of Science (1950-2014) and MEDLINE (1946-2014) using search terms relating to equine colic. Publications were assessed against inclusion and exclusion criteria, and then reviewed using the QUADAS quality assessment tool [1].

Results: The primary search identified 5508 publications relating to equine colic; 976 related to diagnostic tests, 29 met the inclusion criteria and were assessed using the QUADAS tool. Of these, 16 papers reported on peritoneal fluid parameters, 21 on blood parameters, 10 on blood and peritoneal parameters, three on physical and blood parameters and one study on urine parameters. A range of different parameters were evaluated, with the majority of tests only being evaluated in single studies. There were three studies on alkaline phosphatase, two studies on lactate, two on serum amyloid, three studies on tumour necrosis factors and two studies on plasma D dimer. Laila's presentation will provide an overview of the range of studies on different diagnostic tests, highlighting the evidence on tests relate to the differentiation of medical vs surgical colic

References: 1. Whiting, P., Rutjes, A.W.S., Reitsma, J.B., Bossuyt, P.M.M. and Kleijnen, J. (2003) The development of QUADAS: a tool for the quality assessment of studies of diagnostic accuracy included in systematic reviews. *BMC Medical Research Methodology* **3**(25)

Summary 2 – A systematic review of laboratory tests used for the primary diagnosis of colic in the horse

T. Cullen, L. Curtis, G.C.W. England, J.H. Burford, and S.L. Freeman
School of Veterinary Medicine and Science, University of Nottingham, College Road, Sutton Bonington, Loughborough, Leicestershire. LE12 5RD

Reason for performing study: Early identification of surgical cases of colic is critical to improving outcome and welfare. Measurement of lactate in horses with colic has been described for over 20 years, as a measure of poor tissue perfusion and anaerobic glycolysis. *Objectives:* To systematically review and appraise the evidence on diagnostic tests for identifying surgical colics. *Study Design:* Systematic review

Methods: The primary literature search was conducted in CAB Abstracts, WEB of Science and MEDLINE using search terms relating to equine colic. Publications were assessed against inclusion criteria and exclusion criteria, and then reviewed using the QUADAS scoring system.

Results: The primary search identified 5508 publications relating to colic; 42 studies related to the use of lactate in the diagnosis of colic. Two papers met the inclusion criteria (Latson et al. 2005, Yamout et al. 2011) and were assessed using QUADAS[1]. Both papers investigated the use of both plasma and peritoneal lactate to identify ischaemic strangulation obstructions. Both were cross sectional studies, and a total of 71 horses with strangulating lesions were evaluated across the two studies.

Tom's presentation will appraise these two studies on the use of lactate as a diagnostic test for colic and summarise their conclusions.

Study 1

Latson, K. M., Nieto, J. E., Beldomenico, P. M., Snyder, J. R. (2005) Evaluation of peritoneal fluid lactate as a marker of intestinal ischaemia in equine colic. Equine Veterinary Journal. 37(4) 342-346

Reasons for performing study: The most common cause of death as a direct result of colic is acute circulatory failure secondary to intestinal ischaemia. Early and accurate recognition of ischaemic bowel is essential to decrease complications and increase survival. Blood to peritoneal lactate values have been evaluated as a prognostic indicator, but lactate values characterised by type of lesion have not been reported.

Hypothesis: Plasma and peritoneal lactate values are higher in horses with intestinal ischaemia secondary to a strangulating obstruction (ISSO). Methods: Venous blood and peritoneal fluid were collected sequentially from 20 clinically healthy horses and 189 horses admitted for colic during a one-year period. Blood gas, pH, electrolyte (K+, Na+, Cal(++), Cl-), glucose and lactate values were determined for blood and peritoneal fluid samples; other values recorded for peritoneal fluid included gross appearance, total protein and nucleated cell count. Information regarding diagnosis, treatment and outcome was retrieved from the medical records. Results: Peritoneal and plasma levels of lactate were lower in control compared to clinical cases. Horses with ISSO had a higher peritoneal lactate value (8.45 mmol/l) than those with nonstrangulating obstruction (2.09 mmol/l). Factors with the strongest correlations with the presence of ISSO were changes in the gross appearance of the peritoneal fluid and values of peritoneal fluid chloride, pH and log(10) lactate. Conclusions: Analysis of peritoneal fluid gross appearance, pH, lactate and chloride can be used for diagnosis of ISSO. Potential relevance: Peritoneal fluid lactate is a better predictor of ISSO than blood lactate and may aid in early detection of catastrophic peritoneal lesions such as intestinal strangulation and rupture.

Study 2

Yamout, S. Z., Nieto, J. E., Beldomenico, P. M., Dechant, J. E., Lejeune, S., Snyder, J. R. (2011) Peritoneal and plasma D-lactate concentrations in horses with colic. Veterinary Surgery. 40(7). 817-824

Objective: To evaluate the association between peritoneal fluid and plasma D-lactate concentration with variables used in the diagnosis and prognosis of horses with colic. Animals: Clinically healthy horses (n=6) and 90 horses with colic. Study Design: Prospective cross-sectional study. Methods: D-lactate concentration was determined in peritoneal fluid and plasma of all horses. Information on other blood and peritoneal fluid variables, signalment, results from the physical examination, outcome, need for surgery, lesion location, and type was retrieved from medical records. Results: Peritoneal D-lactate concentration was strongly correlated with plasma D-lactate concentration (r=0.71; P<.001). Peritoneal and plasma D-lactate concentrations were positively correlated with peritoneal (r=0.8; P<.001) and plasma L-lactate (r=0.33; P=.001) concentrations, respectively. Peritoneal D-lactate concentration was negatively correlated with survival to discharge (U=430.5; P<.001). Median peritoneal D-lactate concentration of horses with septic peritonitis (455.2 micro mol/L) and

horses with gastrointestinal rupture (599.5 micro mol/L) were higher compared with horses with nonstrangulating obstructions (77.7 micro mol/L). A cut-off concentration of peritoneal D-lactate of 116.6 micro mol/L had a sensitivity of 0.813 and a specificity of 0.651 to differentiate between nonstrangulating and strangulating obstructions. Conclusions: Peritoneal D-lactate concentration may be more useful for identifying horses with strangulating obstructions (high sensitivity, low probability of a false negative) than to ruling out strangulating obstruction (moderate specificity, high probability of a false positive).

Summary 3 - First-line treatment choice and colic survival in the UK: A multi-practice study

T.S.Mair, Bell Equine Veterinary Clinic, Mereworth, Kent, ME18 5GS
and D.J.Mellor, Faculty of Veterinary Medicine, University of Glasgow, Bearsden Road, Bearsden, Glasgow, G61 1QH

*Reasons for performing stud*y*:* There have been very few studies of the relative efficacies of different analgesic drugs used to treat abdominal pain in horses. There have also been few reports of the outcome of colic cases identified in first opinion practice.

Objectives: To document the use of different analgesic drugs by veterinary practitioners in the first-line treatment of colic, and to assess whether the choice of analgesic drug affects the outcome of the case.

Methods: A prospective survey of colic cases examined by veterinary practitioners. Participating veterinarians documented details of each colic case treated over 12 months. Details of the horse, the severity of behavioural colic and clinical findings, the treatments administered and the outcome were recorded.

Results: Details of 1015 colic cases were reported. The commonest diagnoses were “non-specific” colic (27.8%) and spasmodic colic (25.6%). The initial analgesic drug treatment involved a single drug preparation in 528 cases (52.4%), a combination of two drugs in 365 cases (36.2%), three drugs in 77 cases (7.6%), and four drugs in 38 horses (3.8%). 841 horses (82.9%) survived; euthanasia was carried out in 158 horses (15.5%); 16 horses died (1.6%). Surgery was performed in 103 cases (10%). Univariable analysis showed that the outcome (non-survival) was significantly associated with:

age; breed; body weight; severity of colic; duration of colic; heart rate; mucous membrane colour; gastrointestinal sounds; rectal findings; capillary refill time; analgesic drug; recurrence of pain after analgesic treatment. Multivariable modelling showed that outcome (non-survival) was significantly associated with: old age; long duration of colic; severe pain; reduction or absence of gastrointestinal sounds.

Conclusions: A wide range of different analgesic drugs and drug combinations are used as first-line treatment of colic by practitioners. The choice of which analgesic drug or combination of analgesic drugs was used to treat colic was not significantly associated with the outcome of the case. Non-survival was associated with severe signs of pain, lack of response to initial analgesic treatment and older age.

Potential relevance: Valuable clinical data can be obtained using studies conducted by veterinary practitioners. Severe signs of pain and lack of response to initial analgesic treatment are indicators that the horse may require surgery.

Summary 4 - The diagnostic approach of 1016 cases of colic presented to first opinion practitioners, and the differentiation of critical and non-critical cases

L. Curtis, J.H. Burford, J.S.M. Thomas, M.L. Curran, T.C. Bayes, G.C.W. England and S.L. Freeman
School of Veterinary Medicine and Science, University of Nottingham, College Road, Sutton Bonington, Loughborough, Leicestershire. LE12 5RD, UK.

Background: Evidence on the primary evaluation of colic in the horse is required to aid decision-making by veterinary practitioners.

Methods: A 13-month study was carried out to generate a case series describing the clinical presentation and evaluation of colic cases and compare critical and non-critical cases. Report forms were submitted by veterinary practitioners involved in the primary evaluation of colic on the clinical presentation, diagnostic approach, treatment and outcomes of cases.

Pain and behaviour were assessed using a behavioural severity score (0-17, minimum-maximum). Total gut sounds (TGS) were scored 0-12 based on auscultation. Review of

case outcome categorised cases which responded positively to simple medical treatment as non-critical. Cases which required intensive medical treatment, surgical intervention, died or were euthanased were categorised as critical. Multivariable logistic regression was used to identify features of the clinical presentation which were associated with critical cases. Diagnostic test recruitment was analysed using Chi-squared tests.

Results: 1016 case report forms were submitted from 167 veterinary surgeons. The study population had a mean age of 13.5 (median 12.0, range 0-42) years. Mean heart rate was 47 beats/min (median 44, range 18-125), and mean respiratory rate 20 breaths/min (median 16, range 6-100). Median TGS was 5 (range 0-12). On a behavioural severity score, 70.4% scored 0-6 and 29.6% scored 7-12. Rectal examination was performed in 73.8% of cases. The most common treatments were non-steroidal anti-inflammatory drugs (86.9% cases) and spasmolytics (65.6%).
Of eight-hundred-and-twenty-two cases, 76.4% could be classified as non-critical or 23.6% critical (23.6%. Five variables were retained in the final multivariable model: combined pain score: (OR 1.19, p<0.001, 95% CI 1.09-1.30), heart rate (OR 1.06, p<0.001, 95% CI 1.04-1.08), capillary refill time >2.5 seconds (OR 3.21, p=0.046, 95% CI 1.023-10.09), weak pulse character (OR 2.90, p=0.004, 95% CI 1.39-5.99) and absence of gut sounds in ≥ one quadrant (OR 3.65, p<0.001, 95% CI 2.08-6.41).

Conclusions: This is the first study comparing critical and non-critical colic cases on primary presentation to the veterinary practitioner. Pain, heart rate, gastrointestinal borborygmi and simple indicators of hypovolaemia are important clinical variables in the triage of critical cases, and should be considered essential aspects of primary examination.

Summary 5 – Trends in management of horses referred for evaluation of colic: 2004-2013 A.T. Blikslager,* T.S. Mair[†]

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Background: Ever since the economic turmoil of 2008, equine veterinarians have been concerned about the subsequent financial hardship of equine practice, including reduced caseloads and a perceived reduced willingness for owners to give permission for expensive medical or surgical procedures (Ramey, 2012). During the British Equine Veterinary Association Congress 2013, these issues were discussed during a colic panel, prompting the present study.

Objectives: We aimed to document the numbers of horses with colic being referred to two equine hospitals over the last ten years, and to record the numbers undergoing surgery and numbers being euthanased.

Methods: Caseload numbers were compared between a university practice in the United States (NC State) and a private referral practice in the United Kingdom (Bell Equine). The total number of cases referred for evaluation of colic was recorded on a calendar year basis from 2004-2013. Within the population of colic referrals, horses were assigned to one of four groups depending upon the course of treatment following initial assessment: medical colic, surgical exploration with recovery from anesthesia, surgical exploration with intraoperative euthanasia or euthanasia without additional medical or surgical procedures. The caseload within each of the four categories was expressed as a percentage of the total colic caseload for the purposes of comparison.

Results: In 2004, Bell Equine received 150 horses for evaluation of colic, whereas NC State received 266 horses. In 2013, the number of horses referred for evaluation of colic at Bell Equine was 173, representing a 15.3% increase, whereas NC State received 220 horses, representing a 17.3% decline in colic caseload. The most remarkable trends, which were similar between the two practices, were the decline in the number of horses going to surgery for exploration of the abdomen, and the increase in the

number of horses that were euthanased as a proportion of the total colic caseload. For example, at Bell Equine in 2004, 56.0% of the colic caseload underwent surgical exploration with recovery from anesthesia, as compared to 31.2% of the colic caseload in 2013. At NC State in 2004, 28.2% of the colic caseload underwent surgical exploration with recovery from anesthesia, whereas only 19.5% of the caseload were treated similarly in 2013. These reductions in surgical caseload were accompanied by increasing numbers of horses that were euthanased, but euthanasia tended to occur at different time points. For instance, at Bell Equine, 2.7% of the colic referral population was euthanased without further medical or surgical treatment in 2004, as compared to 9.2% in 2013. Alternatively at NC State, the population of horses euthanased following initial workup was 11.3% of the caseload in 2004 and 8.2% in 2013. However, the number of horses euthanased at surgery increased markedly from 7.5% of the colic caseload in 2004 to 17.7% in 2013 at NC State. The percentage of colic patients being euthanased at surgery at Bell Equine varied very little over the 10-year period, accounting for 6.7% of the caseload in 2004 and 6.4% of the caseload in 2013. One positive trend that was noted since 2011 was that the percentage of horses taken to surgery appears to be going up at both practices, with a notable reduction in euthanasia following evaluation at Bell Equine in 2013 and a similar but smaller drop in euthanasia at NC State. One factor that may contribute to decisions with colic patients is the cost of treatment. From available financial data from both practices (2008-2013), the average bill at discharge following colic surgery at Bell Equine increased by 10.5%, whereas the NC State bills increased by 10.3% over the same 5-year time period.

Conclusions: This study revealed a trend at two equine practices toward a decreasing proportion of colic patients going to surgery, which was accompanied by a trend toward increased euthanasia prior to surgery (Bell Equine) or an increasing number of horses being euthanased at surgery (NC State). Over the latter half of the study period, the cost of surgery rose by approximately 10% at both practices, suggesting that factors other than fee increases may have accounted for an increasing trend toward euthanasia of horses with surgical colic. However, evaluation of these data at NC State have prompted tentative plans for a reduction in colic fees for the first time in the institution's history. In addition, specific trends, such as increasing euthanasias following initial evaluation or during surgery should be evaluated to understand the driving forces for these decisions.

Summary 6. Veterinary practitioners' opinions of diagnostic tests for the primary evaluation of colic in the horse.

L. Curtis, I. Trewin, G.C.W. England, J.H. Burford, S.L. Freeman
School of Veterinary Medicine and Science, University of Nottingham, College Road, Sutton Bonington, Loughborough, Leicestershire. LE12 5RD, UK.

Background: There is limited evidence on decision-making in equine colic. The aim of this study was to determine which diagnostic tests veterinary practitioners use in their primary evaluation of colic and what factors affect choice of tests.

Methods: A mixed methods questionnaire was distributed to veterinary surgeons involved in the primary evaluation of horses with colic. The questionnaire related to participants' demographics, opinion of six different diagnostic tests for colic and factors that influence use of different tests. Data analysis included descriptive analysis, thematic analysis of open questions, and statistical analysis using correlation.

Results: 228 responses were analysed. Participants worked in mixed practice (55.7%), first opinion equine (22.8%), first and second opinion equine (17.9%), and referral practice (3.1%). The majority of practitioners (48.2%, 105/218) were very confident when managing a colic case (confidence level 4/5). 'Response to analgesia' was the most commonly used diagnostic test (used in a mean of 87.2% of cases), followed by rectal examination (75.9%), and nasogastric intubation (43.8%). Approach varied between practitioners, and for all tests, responses ranged from 0%- 100% of cases.

Rectal examination was identified as the most important diagnostic test (47.7% practitioners, 83/174). 'Test not required to contribute to diagnosis/treatment' was the most common overall reason for not using diagnostic tests. 'Risk to personal safety' was the most common reason for not using rectal examination. Simple univariable correlations were used to explore the relationships between independent variables and the relative self-estimated frequency that diagnostic tests were performed. There was evidence of an association between the increasing self-assessed confidence level of the practitioner and the estimated frequency of use of rectal examination ($p<0.001$), ultrasound examination ($p<0.001$) and abdominal paracentesis ($p<0.05$). There was evidence of reduced frequency of use of nasogastric intubation as a diagnostic tool with increased years since qualification.

Conclusions: There was variation in practitioners' approaches to colic in the horse, highlighting the need for evidence to support decision-making. Most practitioners used a small range of diagnostic tests and considered that further investigations were not required. Confidence level and type of employment were significantly associated with how frequently practitioners used different diagnostic tests.

Summary 7 – Experiences of half a million rectal examinations. John Newcombe.

John Newcombe has been working in equine reproductive medicine since 1972. He estimates that in 55 years he has performed near to half a million rectal examinations. He will be doing a short presentation about his experiences in performing rectal examinations in the horse, and the incidence of complications in the horses that he has examined.

Summary 8. Clinical decision making in veterinary practice**.** Sally Everitt

In her talk Sally will try to give a brief overview of how we make decisions and how, by making the decision-making process more explicit, we can try to improve our decisions. She will draw on research from other areas but will focus on clinical decisions relating to diagnosis and how this is accomplished in veterinary practice. She will also draw on research findings from her PhD which demonstrated that in comparison to human medicine, decision making in veterinary practice appears to be more a negotiated activity, as the veterinary surgeon has to consider a number of factors including that the animal owner is both paying for veterinary services (directly or indirectly through insurance) and may be involved in carrying out much of the care.

Appendix P: Form used to record consensus statements during multi-disciplinary workshops

Table Number	Final Statement	Number of members agreed (e.g. 4/6)	Source of information (Presentation, research study, experience, opinion etc)

Appendix Q: Participant feedback from multidisciplinary Workshop One

Workshop and Presentations	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Instruction packs were clear and concise	15	12	1		
Information given beforehand meant I felt well prepared for the workshop	14	13	1		
Presentations were clear and at an appropriate level for me to understand	18	9	1		
Discussion groups enabled me to listen and contribute	19	8			
The facilitator gave satisfactory responses to any questions asked	19	8	1		
The workshop was well structured	18	9	1		
Workshop staff were friendly approachable and knowledgeable	27	1			
I am pleased I attended the workshop	25	3			
Organisation of the Day	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
The workshop started and finished at appropriate times	14	12			
There were sufficient comfort breaks	17	9			1
The facilities were acceptable	21	6			
The food was of the quality I expected	21	2	1		
Directions of the course location were appropriate	19	5	1	1	1

What did you find most useful about this session?	**Number of same comments**
Wide range of opinions from different backgrounds	3
The presentations	2
The opportunity to discuss with owners and experts	10
Sharing and learning additional symptoms and potential progression of serious colic	7
Listening to others' experiences and perspectives	10
Insight into current research and future implementation	2
Everyone involved equally	1
Amazing food	1
What could have been improved?	
More discussion time	8
The coffee	1
Complex reading matter	1
No directions to car park	2
Presentations directed at owners, not necessary for vets	1
Additional comments	
The BHS are happy to stay involved with the project so please let me know if we can provide additional support	
A forum or webpage to exchange details, knowledge, ideas etc.	
Thank you for holding such a professional & informative workshop. It was lovely speaking with people that had experienced similar problems. I really hope that the Workshops can educate owners and improve the process for the poor horses that suffer from this awful illness.	
Thank you very much for a very informative afternoon on Saturday	

Appendix R: Self designed quality appraisal tool for a systematic review of risk factors for equine abdominal pain.

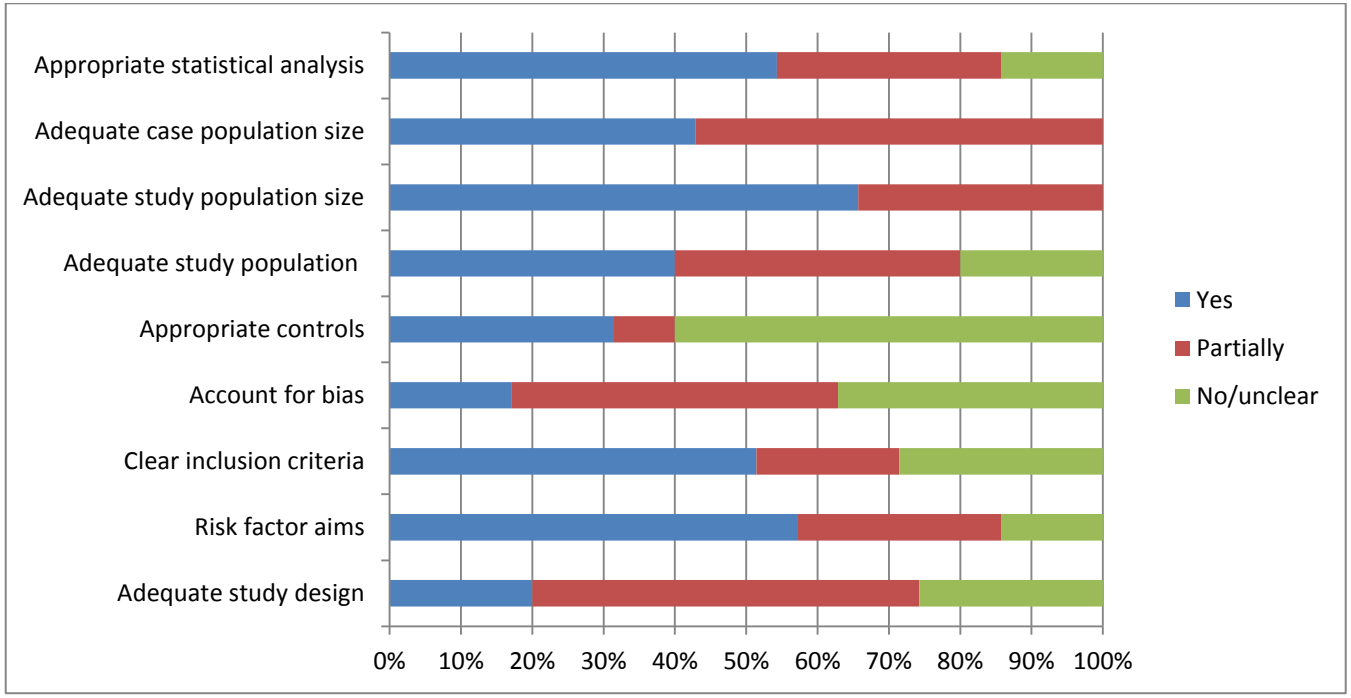
Criteria	Checklist	No/Unclear	Partially	Yes
1	Is the study design adequate for an investigation of risk factors?	Partially/not clearly defined/ Case series	Retrospective cohort, case-control or cross-sectional study (assessing prevalence or incidence).	Prospective cohort study
2	Did the study aim to identify a risk of colic?	No. Case studies or other studies with no mention of causes or risk factors in title, aims, objectives or hypothesis and studies which are solely concerned with diagnosis and treatment.	Partially, study was a general health survey, or epidemiological study.	Yes, the primary aim of the paper was to identify a colic risk factor or cause
3	Are clear inclusion/exclusion criteria defined and appropriate?	No definition of colic. No exclusion criteria	Partially. Definition/ description of colic present	Definition/ description of colic present and exclusion criteria
4	Did the study account for bias or errors? *	No accounting for selection or measurement bias	Partially. Accounting of selection or measurement bias	Yes. Accounting for selection and measurement bias
5	Was the selection of controls appropriate?	No	Partially. Control selected from same population or randomised or at least 1:1 case control or combination of two criteria	Yes. Control selected from same population, randomised and at least 1:1 case control
6	Was the study population appropriate for a general population estimation of a risk factor/s?	One hospital/veterinary practice/farm/centre, or one breed or case type.	Many breeds or case types, and one hospital/veterinary practice/farm/centre.	Generalised, multi-centric.
7	Was the overall study population size adequate?	10 horses or less were studied	11-200 horses were studied	Over 200 horses were studied
8	Was the colic case population size adequate?	10 horses or less were studied	11-200 horses were studied	Over 200 horses were studied
9	Was statistical analysis appropriate and clearly described?	No statistical analysis was described	Univariate analysis was carried out, or multivariate analysis without controlling for confounding and interactions.	Multivariate analysis was carried out, controlling for confounding and interactions

Papers that do not fulfil requirements will fall into the next highest category. * Selection bias includes incomplete records/ missing data, short duration (< 1yr), bias within population

Appendix S: Quality assessment results for 35 publications in a systematic review of risk factors for equine colic.

	Quality Criteria								
Papers	Adequate study design	Risk factor aims	Clear inclusion criteria	Account for bias	Appropriate controls	Adequate study population	Adequate study population size	Adequate case population size	Appropriate statistical analysis
Abutarbush *et al.,*(2005)	-	/	+	-	-	/	+	+	/
Alexander and Haines, (2012)	-	-	/	-	-	-	/	/	-
Archer *et al.,*(2006)	-	+	-	/	-	/	+	+	+
Cohen and Peloso, (1996)	/	+	+	+	+	+	+	+	+
Cohen *et al.,* (1999)	/	+	+	+	+	+	+	+	+
Cohen *et al.,*(1995)	/	+	+	+	+	+	+	+	+
Egenvall *et al.,* (2008)	-	/	+	-	-	/	+	+	+
Fielding and DeChant, (2012)	-	-	-	-	-	-	/	/	/
Hassanpour *et al.,* (2007)	/	+	-	-	-	+	+	+	/
Hillyer and Mair, (1997)	-	/	+	-	-	/	/	/	-
Hillyer *et al.,*(2001)	/	/	-	/	-	/	+	+	+
Hudson *et al.,* (2001)	/	+	/	/	+	+	+	/	+
Ireland *et al.,*(2011)	+	/	/	/	-	+	/	/	+
Kaneene *et al.,* (1997)	+	+	+	+	-	+	+	/	+
Kaya *et al.,* (2009)	/	+	/	-	/	/	+	+	+
LeBlond *et al.,* (2002)	/	+	+	/	+	+	+	+	+
Mair and Hillyer, (1997)	-	-	+	/	-	/	/	/	-
Malamed *et al.,*(2010)	/	+	+	-	+	/	+	+	+
Mehdi and Mohammad, (2006)	+	+	-	-	-	+	/	/	/
Morris *et al.,*(1989)	/	/	-	/	-	/	+	/	/
Patipa *et al.,*(2012)	/	+	+	-	-	-	+	/	+
Proudman and Edwards, (1993)	/	+	-	/	+	/	+	/	+
Proudman and Holdstock, (2000)	/	+	-	/	+	-	/	/	/
Proudman, (1991)	/	/	/	/	/	/	/	/	/
Rabuffo *et al.,* (2009)	/	-	+	/	/	/	/	/	/
Reeves *et al.,* (1989)	/	+	+	/	+	/	+	+	/
Reeves *et al.,* (1996)	/	+	+	+	+	+	+	+	+
Scantlebury *et al.,* (2011)	+	+	+	/	-	+	/	/	+
Senior *et al.,*(2004)	/	+	+	/	+	-	+	/	+
Tinker *et al.,* (1997a)	+	+	/	/	-	+	+	/	+
Tinker et al., (1997b)	+	/	-	/	-	+	+	/	/
Traub-Dargatz *et al.,* (2001)	+	+	+	+	-	+	+	+	+
Uhlinger, (1990)	/	/	+	-	-	-	/	/	/
Voigt *et al.,* (2009)	-	/	/	-	-	/	+	+	-
Walmsley *et al.,* (2011)	-	-	-	-	-	-	/	/	-

Appendix T: Combined quality assessment results for 35 publications in a systematic review of risk factors for equine colic.



"Come to the edge", he said.

It's too high!

"Come to the edge", he said.

I might fall!

"Come to the edge", he said

And I did,

And he pushed me.

And I flew.....

- Adapted from Christopher Logue